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'SIMPLIFIED' VLF/LF MODE CONVERSION COMPUTER PROGRAMS: GRNDMC A--ETC(U)

JAN 80 D G MORFITT MIPR-80-563

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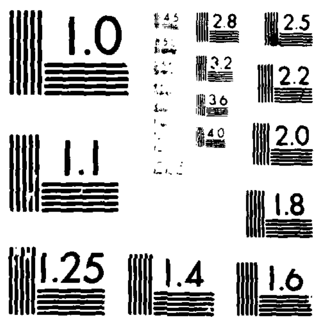

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Technical Report 514

"SIMPLIFIED" VLF/LF MODE CONVERSION COMPUTER PROGRAMS; GRNDMC AND ARBNMC

DG Morfitt

January 1980

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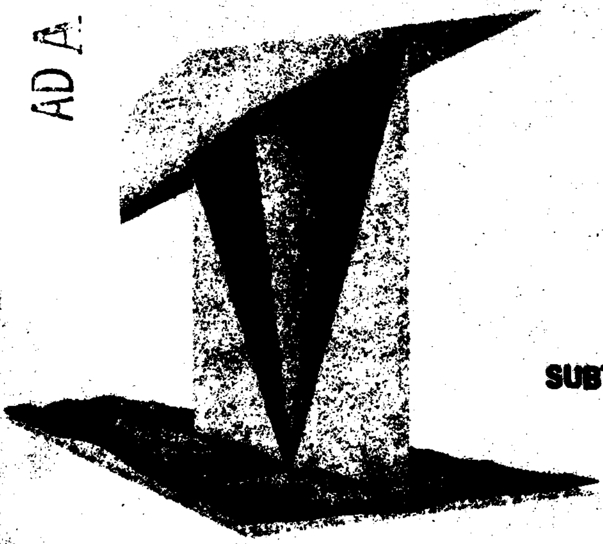

NAVAL OCEAN SYSTEMS CENTER
SAN DIEGO, CALIFORNIA 92152

NAVAL OCEAN SYSTEMS CENTER, SAN DIEGO, CA 92152

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SL GUILLE, CAPT, USN
Commander

HL BLOOD
Technical Director

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20. ABSTRACT (Continued)

(E_z, E_x and E_y) generated by an electric dipole of arbitrary orientation and height within the guide. The ARBNMC program treats air-to-air, ground-to-air or air-to-ground vlf/lf problems. It will also handle ground-to-ground propagation but is much less economical to run than GRNDMC.

"SIMPLIFIED" VLF/LF MODE CONVERSION
COMPUTER PROGRAMS; GRNDMC AND ARBNMC

D. G. Morfitt

ABSTRACT

The computer programs GRNDMC and ARBNMC numerically determine vlf/lf mode conversion coefficients and mode sums for an earth-ionosphere waveguide which is inhomogeneous along the direction of propagation. GRNDMC generates values of the vertical electric field, E_z, at the ground as produced by a ground based vertical dipole source. ARBNMC calculates at an arbitrary height within the guide, all three electric field components (E_z, E_x and E_y) generated by an electric dipole of arbitrary orientation and height within the guide. The ARBNMC program treats air-to-air, ground-to-air or air-to-ground vlf/lf problems. It will also handle ground-to-ground propagation but is much less economical to run than GRNDMC.

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I. INTRODUCTION

This outline is designed to help a knowledgeable user run the NOSC "simplified" mode conversion computer programs, GRNDMC and ARBNMC. They are modified and improved versions of those programs originally developed and described in references (1) and (2), respectively. The improvements include a considerable savings in computer core storage (more than a factor of three in the case of ARBNMC), an increase of the number of waveguide slabs from 25 to essentially an unlimited number, better formatting of the input data, especially in the reduction of from three to two cards per mode, an increase in the number of allowable modes from 5 to 20, and the number of modes to be considered may vary from one ionospheric slab to another.

The computer programs described in references 1 and 2 were developed for calculating vlf/lf field strengths in the earth-ionosphere waveguide when allowance must be made for horizontal inhomogeneity in the direction of propagation. They, GRNDMC and ARBNMC, are particularly relevant to the problem of propagating across the sunrise and sunset terminators and for propagation in an artificially disturbed environment. All of these programs are based upon a slab model, assume waveguide invariance in the direction normal to the great circle path between transmitter and receiver, and neglect reflections resulting from inhomogeneity along the direction of propagation. The field calculations, principally through waveguide modal constant inputs, allow for vertical inhomogeneity as well as anisotropy of the ionosphere.

In the GRNDMC program, field strength calculations or mode sums are generated for the vertical electric field, E_z, at the ground produced by a ground based vertical dipole. ARBNMC calculates all electric field components E_z, E_x and E_y at any receiver height within the guide (x-z is the plane of propagation) generated by electric dipole exciters of arbitrary orientation located at any height within the guide. Thus air-to-air, ground-to-air, air-to-ground, and ground-to-ground vlf/lf propagation in a horizontally inhomogeneous waveguide channel may be treated using the ARBNMC program.

Familiarity is assumed with references 4 and 5 which describe Fortran programs for obtaining waveguide mode constants and the excitation factors for electric dipoles of arbitrary orientation located at any height within the earth-ionosphere waveguide. Crucial outputs from these programs are the ground eigenangles and four independent quantities from which a tensor array

of nine excitation factors relating to end-on, broadside or vertical dipole excitation of E_z, E_x and E_y may be determined. These quantities for each mode and slab serve as input to the GRNDMC and ARBNMC programs. These quantities are obtained from the programs described in references 4 and 5 by setting the variable NPUNCH = 1.

Principal outputs of the present programs are mode conversion coefficients (in a generalized sense) and mode sum plots as a function of distance from the transmitter. Since the mode conversion coefficients are independent of the location of the horizontal inhomogeneity relative to the transmitter, provision is made for moving the inhomogeneity in increments and plotting mode sums for the incremented distances (this option is useful only if the ground conductivity and geomagnetic orientation may be regarded as constant over the path).

In section II a general description of the program options is given. Section III summarizes the relevant formulae. A description of the program input, output and operating procedures is given in section IV. Results are given in sections VI and VII. Appendix 1 gives a FORTRAN listing of GRNDMC while Appendix 2 gives a FORTRAN listing of ARBNMC.

II. GENERAL PROGRAM DESCRIPTIONS

The mode conversion programs, GRNDMC and ARBNMC, provide approximate methods for numerically determining mode conversion coefficients and mode sums for a slab model of the earth-ionosphere waveguide which is inhomogeneous along the direction of propagation (i.e., along the great circle path between transmitter and receiver). Invariance normal to the transmitter-receiver line is assumed in the calculations and reflections due to the horizontal inhomogeneity are neglected. The computational procedure used in these programs is referred to as "simplified" in that a full wave fields program for "height gain" terms is not required. The associated height gain integrals are instead performed analytically as contrasted to the more accurate full wave integration schemes used in other less simplified propagation models, such as described in reference (3).

Mode conversion programs are particularly relevant for propagation across the sunrise (or sunset) terminator and for propagation in an artificially disturbed environment. The field strength calculations allow for vertical inhomogeneity as well as anisotropy of the ionosphere.

Two distinct options are available with the present GRNDMC and ARBNMC programs. One option is for field calculations (amplitude and phase) as a function of range for a fixed location of the horizontal inhomogeneity. The second allows for field calculations at two distinct receiving points along the same great circle path as a function of position of the horizontal inhomogeneity. An important limitation of this second option is that the calculations are useful only if the ground conductivity and the geomagnetic parameters change little over the path.

GRNDMC (ground based propagation via mode conversion) is a modified version of the program described in reference 1. It generates values of the vertical electric field, E_z, at the ground as produced by a ground based vertical dipole source. The program output consists of mode conversion coefficients and a field strength plot as a function of transmitter receiver distance or as a function of location of the horizontal inhomogeneity relative to the transmitter for fixed point transmissions.

ARBNMC (for airborne propagation via mode conversion) is a modified version of the program described in reference (2). ARBNMC differs from GRNDMC

to the extent that it can be used to calculate all electric field components E_z, E_x and E_y for any receiver height within the guide (x-z is the plane of propagation) for electric dipole exciters of arbitrary orientation located at any height within the guide. Thus air-to-air, ground-to-air, air-to-ground, and ground-to-ground vlf/lf propagation in a horizontally inhomogeneous waveguide channel may be treated using the ARBNMC program. The principal outputs of this program are mode conversion coefficients and mode sum plots as a function of distance from the transmitter for the three electric field components for four orientations of the electric dipole exciter. The transmitter and receiver must be within the earth curvature dominated portion of the guide (below the ionosphere) but otherwise their altitude is arbitrary. Since the mode conversion coefficients are independent of the location of the horizontal inhomogeneity relative to the transmitter, provision is made for moving the inhomogeneity in increments and plotting mode sums for the incremented distances (again, this option is useful only if the ground conductivity and geomagnetic orientation may be regarded as constant over the path).

III. SUMMARY OF THE EQUATIONS:

In the propagation of vlf and lf terrestrial radio waves to great distances, the waves are confined within the space between the earth and the ionosphere. This space acts as a waveguide, and the "waveguide concept" is applicable for characterizing the propagated fields as a function of distance.

The waveguide mode method obtains the full wave solution for a waveguide that has the following characteristics: (1) arbitrary electron and ion density distributions and collision frequency (with height) and (2) a lower boundary which is a smooth homogeneous earth characterized by an adjustable surface conductivity and dielectric constant. This method also allows for earth curvature, ionospheric inhomogeneity, and anisotropy (resulting from the earth's magnetic field).

The energy within the waveguide is considered to be partitioned among a series of modes. Each mode represents a resonant condition, i.e., for a discrete set of angles of incidence of the waves on the ionosphere, resonance occurs and energy will propagate away from the source. The complex angles (Θ) for which this occurs are called the eigenangles (or "modes"). These are obtained using the "full-wave" procedures described in references 4 and 5 by solving the determinantal equation (i.e., the modal equation):

$$F\ (\Theta) = \left| \underset{\sim}{R}_d(\Theta)\ \overline{\underset{\sim}{R}}(\Theta) - 1 \right| = 0 \qquad (1)$$

$$\text{where } \underset{\sim}{R}_d\ (\Theta) = \begin{bmatrix} {}_{\parallel}R_{\parallel\ d}\ (\Theta) & {}_{\perp}R_{\parallel\ d}\ (\Theta) \\ {}_{\parallel}R_{\perp\ d}\ (\Theta) & {}_{\perp}R_{\perp\ d}\ (\Theta) \end{bmatrix} \qquad (2)$$

is the complex ionospheric reflection coefficient matrix looking up into the ionosphere from height "d" and

$$\underset{\sim}{\overline{R}}_d(\Theta) = \begin{bmatrix} {}_{\parallel}\overline{R}_{\parallel\,d}(\Theta) & 0 \\ 0 & {}_{\perp}\overline{R}_{\perp\,d}(\Theta) \end{bmatrix} \tag{3}$$

is the complex reflection matrix looking down from height "d" towards the ground.

The notation $\parallel$ for the R's and $\overline{R}$'s denotes vertical polarization while the notation $\perp$, denotes horizontal polarization. The first subscript on the R's refers to the polarization of the incident wave while the second applies to the polarization of the reflected wave.

The individual terms of equations (2) and (3) are:

${}_{\parallel}R_{\parallel}$ = the ratio of the reflected field in the plane of incidence to the incident field in the same plane.

${}_{\perp}R_{\perp}$ = the ratio of the reflected field perpendicular to the plane of incidence to the incident field perpendicular to the plane of incidence.

${}_{\parallel}R_{\perp}$ = the ratio of the reflected field perpendicular to the plane of incidence to the incident field in the plane of incidence.

${}_{\perp}R_{\parallel}$ = the ratio of the reflected field in the plane of incidence to the incident field perpendicular to the plane of incidence.

The ionospheric reflection matrix, R_d (equation 2) at height, d, may be obtained (from references 4 or 5) by numerical integration of differential equations given by reference 6. The differential equations are integrated by a Runge-Kutta technique starting at some height above which negligible reflection is assumed to take place. The initial condition for the integration, i.e.,the starting value of R, is taken as the value of R for a sharply-bounded ionosphere at the top of the given electron density and collision frequency profiles. The method for obtaining this starting solution

is described in reference 7. The term $\overline{R}_d$ may be calculated (as in references 4 or 5) by the methods described in reference 8 in terms of solutions to Stoke's equation and their derivatives. That is, the ground reflection coefficient matrix $\overline{R}_d$, as given in equation (3), is determined in terms of independent solutions, h_1 and h_2 to Stokes' equation

$$\frac{d^2h_{1,2}}{dz^2} + zh_{1,2} = 0 \qquad (4)$$

where the functions h_1 and h_2 are modified Hankel functions of order 1/3 (which are linearly related to Airy functions) as defined by the Computation Laboratory, Cambridge, Massachusetts, reference 9.

The propagation geometry, upon which GRNDMC and ARBNMC are based, is shown in Figure 1. In this coordinate system the direction of stratification is the z direction and the direction of propagation is in the x - z plane. The direction of z, which is the altitude coordinate measured normal to the curved earth's surface, is taken positive into the ionosphere. Positive x is the direction of propagation and y is normal to the plane of propagation. Thus, the fields exhibit no y dependence but have a dependence of x of the form $\exp(-iK \sin \Theta\, x)$ where K is the magnitude of the free-space propagation vector, Θ is the angle between the direction of the propagation vector and the z direction at a point in the stratified medium where the index of refraction is unity. All field quantities are assumed to have an $\exp(i\omega t)$ dependence where ω is the angular frequency. The radiating dipole source for the propagated fields is denoted in Figure 1 by $\vec{M}$. The dipole is oriented within the earth-ionosphere waveguide by the inclination angle γ and azimuthal angle ϕ.

For a vertical dipole, $\gamma = 0^o$ and $\phi = 0^o$. For a horizontal dipole $\gamma = 90^o$ and since ϕ is the angle between the direction of the horizontal dipole and the direction of propagation, $\phi = 0^o$ represents end-fire and $\phi = 90^o$ represents broadside launching.

The procedure used in the mode conversion model segments the earth-ionosphere waveguide into M cascaded uniform waveguides (Figure 2) where the propagation characteristics do not change within any segment. The slabs are

numbered from left to right with the total number of slabs being denoted as M. The slab labeled NTR is the slab containing the transmitter. The modal equation, equation 1, is solved by the method of either references 4 or 5 for as many modes (eigenangles, Θ_j) as desired in each waveguide segment (or slab). The model allows for an arbitrary number of modes on each side of any given boundary. At any transition region (i.e., slab boundary) energy scatters from a given mode into several other modes in the adjoining slab.

Subject to the assumptions of invariance in the y-direction and the neglection of reflections from horizontal inhomogeneities, mode conversion coefficients may be computed by enforcing the boundary condition (at each slab interface) that all tangential field components must be continuous. Also, the mode conversion algorithm formulation assumes that a unit amplitude wave exists for each mode k in the transmitter region (slab NTR of figure 2). The quantities a^p_{jk} relate the energy from an incident mode, k, in the transmitter slab to j-th mode in slab p.

The "accumulative" mode conversion coefficient a^p_{jk} for the p-th slab associated with conversion from the k-th to the j-th mode expressed in terms of the coefficients for the previous (p-1)-th slab may be written in the form (reference 10).

$$\sum_{j=1}^{J} a^p_{jk} \, I^{p,p}_{n,j} = I^{p,p-1}_{n,k}, \quad p = \text{NTR} + 1 \tag{5}$$

$$= \sum_{j=1}^{J} a^{p-1}_{jk} \left[-iKs^{p-1}_j (x_p - x_{p-1})\right] I^{p,p-1}_{n,k}, \quad \text{NTR} + 1 \leq p < M$$

where i = (-1) , K is the free-space wave number, S_j is the sine of the j^{th} eigenangle for the p^{th} slab, and J is the total number of modes assumed to be important in the total field determinations.

A simplified explanation of equation (5) is demonstrated in figure 3. In the figure some important variables are:

The "normalized conversion coefficient" for the p-th slab, $\bar{\underset{\sim}{I}}^{p}$.

$$\begin{array}{c} \\ j\downarrow \end{array}\begin{array}{c} i\rightarrow \\ \begin{pmatrix}\bar{I}^{p}_{ji}\end{pmatrix} \end{array} = \begin{array}{c} \\ i\downarrow \end{array}\begin{array}{c} j\rightarrow \\ \begin{pmatrix}I^{p,p}_{jj}\end{pmatrix}^{-1} \end{array} \cdot \begin{array}{c} \\ j\downarrow \end{array}\begin{array}{c} i\rightarrow \\ \begin{pmatrix}I^{p,p-1}_{ji}\end{pmatrix} \end{array} \quad (6)$$

where all terms are matrices.

The "total or accumulative conversion coefficient" for the p-th slab, a^{p}.

$$\begin{array}{c} \\ j\downarrow \end{array}\begin{array}{c} k\rightarrow \\ \begin{pmatrix}a^{p}_{jk}\end{pmatrix} \end{array} = \begin{array}{c} \\ j\downarrow \end{array}\begin{array}{c} i\rightarrow \\ \begin{pmatrix}\bar{I}^{p}_{ji}\end{pmatrix} \end{array} \quad (7)$$

$$\cdot\; i\downarrow \begin{array}{c} i\rightarrow \\ \begin{bmatrix} \exp[-i\frac{2\pi}{\lambda}\, S^{p-1}_{1}(x_p - x_{p-1})] & 0 & 0 \\ 0 & \ddots\; \exp[-i\frac{2\pi}{\lambda}\, S^{p-1}_{i}(x_p - x_{p-1})]\; \ddots & 0 \\ 0 & 0 & \exp[-i\frac{2\pi}{\lambda}\, S^{p-1}_{I}(x_p - x_{p-1})] \end{bmatrix} \end{array}$$

$$\cdot\; \begin{array}{c} \\ i\downarrow \end{array}\begin{array}{c} k\rightarrow \\ \begin{pmatrix}a^{p-1}_{ik}\end{pmatrix} \end{array}$$

where again all terms are matrices. The indices are $j = 1, 2, 3 \ldots J$ for the modes in slab p; $i = 1, 2, 3 \ldots I$ for the modes in slab P-1; and $k = 1, 2, 3 \ldots K$ to the modes in the transmitter slab NTR.

If it is assumed that the transmitter is located in slab 1 (see figure 3), the required expansions for the first 4 slabs, supposing 3 modes, are:

$\underset{\sim}{a}^1 = \underset{\sim}{U}$ (i.e., the unit matrix)

$$\underset{\sim}{a}^2 = \bar{\underset{\sim}{I}}^{\,2} \cdot \left\{ \begin{array}{ccc} \exp(-i\frac{2\pi}{\lambda}\, S_1^1(x_2 - 0)) & 0 & 0 \\ 0 & \exp(-i\frac{2\pi}{\lambda}\, S_2^1(x_2 - 0)) & 0 \\ 0 & 0 & \exp(-i\frac{2\pi}{\lambda}\, S_3^1(x_2 - 0)) \end{array} \right\} \cdot \underset{\sim}{a}^1$$

$$\underset{\sim}{a}^3 = \bar{\underset{\sim}{I}}^{\,3} \cdot \left[\begin{array}{ccc} \exp(-i\frac{2\pi}{\lambda}\, S_1^2(x_3 - x_2)) & 0 & 0 \\ 0 & \exp(-i\frac{2\pi}{\lambda}\, S_2^2(x_3 - x_2)) & 0 \\ 0 & 0 & \exp(-i\frac{2\pi}{\lambda}\, S_3^2(x_3 - x_2)) \end{array} \right] \cdot \underset{\sim}{a}^2$$

$$\underset{\sim}{a}^4 = \bar{\underset{\sim}{I}}^{\,4} \cdot \left[\begin{array}{ccc} \exp(-i\frac{2\pi}{\lambda}\, S_1^3(x_4 - x_3)) & 0 & 0 \\ 0 & \exp(-i\frac{2\pi}{\lambda}\, S_2^3(x_4 - x_3)) & 0 \\ 0 & 0 & \exp(-i\frac{2\pi}{\lambda}\, S_3^3(x_4 - x_3)) \end{array} \right] \cdot \underset{\sim}{a}^3$$

where λ is the free space wavelength. The symbol under the various variables (i.e., a and $\overline{I}$) denotes a matrix.

Critical for the solution of the system of equation (5) is the evaluation of the integral

$$I_{jk}^{m,p} = \int_{-\infty}^{\infty} A_j^{mt} \cdot G_k^p \, dz \qquad (9)$$

where the t denotes the adjoint and G^p is a four-element column matrix of height gains for the y and z components of the electric and magnetic field strength of the k^{th} mode in the p^{th} slab.

The column vector G_k^p (z) is given by:

$$G_k^p(z) = \begin{pmatrix} e_{yk}^p(z) \\ e_{zk}(z) \\ h_{yk}^p(z) \\ h_{zk}^p(z) \end{pmatrix} \qquad (10)$$

The term A_j^m is a four-element column matrix of height gains for an appropriate adjoint waveguide (see reference 11).

In the mode conversion model the height gain elements of A are assumed to be simply rearrangements of the elements of G and are expressed below a height b in the guide in terms of the modified Hankel functions of order 1/3. The crucial integrals in (5) are then given in reference 10 by

$$I_{jk}^{m,p} = (S_j^m + S_k^p) \cdot \int_o^{TOPHT} (e_{yj}^m \cdot e_{yk}^p + J_{yj}^m \cdot H_{yk}^p) \, dz \qquad (11)$$

In arriving at the final form of Equation (11), the height gains below z = 0 and above z = TOPHT have been discarded. Also, introduced is the relation:

$$H_y(z) = e^{-\alpha z/2} h_y \qquad (12)$$

It can then be shown that in the earth curvature dominated portion of the guide, H_y is linearly expressible in terms of solutions to Stokes' equation. This fact is also true for the e's so that if the e's and H's are assumed to obey Stokes' equation in the range $0 \leq z \leq$ TOPHT, Equation (11) becomes

$$I^{m,p}_{j,k} \simeq \frac{1}{K}\left(\frac{\alpha}{K}\right)^{1/3} \frac{1}{(S^m_j - S^p_k)} \left[e^k_{yk} \frac{de^m_{yh}}{dq} - e^m_{yj} \frac{de^p_{yk}}{dq} + H^p_{yk} \frac{dH^m_{yj}}{dq} - H^m_{yj} \frac{dH^p_{jk}}{dq}\right]^b_o$$

if $m \neq p$ and/or $j \neq k$

$$\simeq \frac{2S^m_j}{K} \left[\left(\frac{de^m_{yj}}{dq}\right)^2 + \left(\frac{dH^m_{yj}}{dq}\right)^2 + q((e^m_{yj})^2 + (H^m_{yj})^2)\right]^b_o \tag{13}$$

if $m = p$ and $j = k$

where e_y and H_y are given in terms of modified Hankel functions of order 1/3. Explicitly, these relationships are

$$H_y = \frac{F_1 h_1(q_b) + F_2 h_2(q_b)}{F_1 h_1(q_o) + F_2 h_2(q_o)} \tag{14}$$

$$e_y = \frac{F_3 h_1(q_b) + F_4 h_2(q_b)}{F_3 h_1(q_o) + F_4 h_2(q_o)} \cdot f \tag{15}$$

where "b" = TOPHT in equations (13), (14) and (15). The terms F_1, F_2, F_3 and F_4 are given by equation (16) through (19).

$$F_1 = -\left\{H_2(q_o) - i\,\frac{n_o^2}{Ng^2}\left(\frac{aK}{2}\right)^{1/3}(N_g^2 - S^2)^{1/2}\,h_2(q_o)\right\} \quad (16)$$

$$F_2 = H_1(q_o) - i\,\frac{n_o^2}{Ng^2}\left(\frac{aK}{2}\right)^{1/3}(N_g^2 - S^2)^{1/2}\,h_1(q_o) \quad (17)$$

$$F_3 = -\left\{h_2'(q_o) - i\left(\frac{aK}{2}\right)^{1/3}(N_g^2 - S^2)^{1/2}\,h_2(q_o)\right\} \quad (18)$$

$$F_4 = h_1'(q_o) - i\left(\frac{aK}{2}\right)^{1/3}(N_g^2 - S^2)^{1/2}\,h_1(q_o) \quad (19)$$

$$q_z = \left(\frac{2}{aK}\right)^{-2/3}\left(C^2 - \frac{2}{a}(h-z)\right) \quad (20)$$

$$H_j(q) = h_j'(q) + \frac{1}{2}\left(\frac{2}{aK}\right)^{2/3} h_j(q)\ ;\ j = 1,2 \quad (21)$$

$$n_z^2 = 1 - \frac{2}{a}(h-z) \quad (22)$$

$$N_g^2 = \frac{\varepsilon}{\varepsilon_o} - i\,\frac{\sigma}{\omega\sigma_o} \quad (23)$$

where:

C = cosine of the angle of incidence at height h

h = the height at which the modified refractive index is taken to unity

K = the free space wave number

$\varepsilon/\varepsilon_o$ = dielectric constant of the ground

σ = the ground conductivity

ω = the circular radio frequency

a = the earth's radius

The subscript on q represents the value of z at which q is evaluated. For example, q_o means that (20) is to be evaluated for z = 0 and q_b means that (20) is to be evaluated at z = b. Similarly, the subscript on n^2 represents the value of z for which (22) is to be evaluated.

Again, the functions h_1 and h_2 are modified Hankel functions of order 1/3 as defined by the computation Laboratory at Cambridge, Massachusetts, and the primes on these quantities denote derivatives with respect to the argument.

The variable "b" in equations (20) and (22) is defined as the effective ionospheric height. The value to be assigned to this variable has been determined (reference 1) to be that height level for which the conductivity parameter, ω_r, is:

$$\omega_r = 2.5 * 10^5 \text{ sec}^{-1} \tag{24}$$

This value of "b" is the reference height (h'), as defined by Wait (reference 12) in terms of exponential profiles. In the present programs, the value of "b" is allowed to vary from slab to slab.

The column vector $G_k(z)$ of equation (10) is uniquely defined by normalizing the y component of the rf magnetic field to unity at the ground and by introducing the proper amount of TE wave at the ground which from mode theory is given in reference 10 by:

$$f = \frac{e_y}{h_y} = \left[\frac{(1 + {}_\perp\bar{R}_\perp)(1 - {}_\parallel R_\parallel \, {}_\parallel\bar{R}_\parallel)}{(1 + {}_\parallel\bar{R}_\parallel)\, {}_\perp R_\parallel \, {}_\perp\bar{R}_\perp}\right]_{d=0} = \left[\frac{(1 + {}_\perp\bar{R}_\perp)\, {}_\parallel R_\perp \, {}_\parallel\bar{R}_\parallel}{(1 + {}_\parallel\bar{R}_\parallel)(1 - {}_\perp R_\perp \, {}_\perp R_\perp)}\right]_{d=0} \tag{25}$$

This value of "f" is to be substituted into equation (15).

Inputs to the GRNDMC and the ARBNMC programs for each slab "P" and each mode "j" in the slab are the ground eigenangles (Θ'_j)'s and the T_j's as defined below. The T_j's are readily obtainable from either of the mode finding programs of references 4 or 5, as are the ground eigenangles. These "T" quantities are:

$$T_1 = \left[\frac{S^{1/2}(1 + {}_{\parallel}\overline{R}_{\parallel})^2 (1 - {}_{\perp}R_{\perp}\ {}_{\perp}\overline{R}_{\perp})}{F'(\Theta_j)\ {}_{\parallel}\overline{R}_{\parallel}\ D_{\parallel}} \right]_d \tag{26}$$

$$T_2 = \left[\frac{S^{1/2}(1 + {}_{\perp}\overline{R}_{\perp})^2 (1 - {}_{\parallel}R_{\parallel}\ {}_{\parallel}\overline{R}_{\parallel})}{F'(\Theta_j)\ {}_{\perp}\overline{R}_{\perp}\ D_{22}} \right]_d \tag{27}$$

$$T_3 = \left[\frac{S^{1/2}(1 + {}_{\parallel}\overline{R}_{\parallel})(1 + {}_{\perp}\overline{R}_{\perp})\ {}_{\parallel}R_{\perp}}{F'(\Theta_j)\ D_{12}} \right]_d \tag{28}$$

$$T_4 = \left[\frac{{}_{\perp}R_{\parallel}}{{}_{\parallel}R_{\perp}} \right]_d \tag{29}$$

where S is the sine of the eigenangle at the reference height "h" and $F'(\Theta_j)$ is the derivative of the mode equation, equation 1, evaluated at the eigenangle, Θ_j. The R and $\overline{R}$'s represent, respectively, elements of the reflection matrix looking into the ionosphere and towards the ground from the level z = d. Consistent with the usual notation, the first subscript refers to the polarization of the incident wave and the second subscript refers to the polarization of the reflected wave and

$$D_{11} = (F_1h_1(q_d) + F_2h_2(q_d))^2 \tag{30}$$

$$D_{12} = (F_1h_1(q_d) + F_2h_2(q_d)\ (F_3h_1(q_d) + F_4h_2(q_d)) \tag{31}$$

$$D_{22} = (F_3h_1(q_d) + F_4h_2(q_d))^2 \tag{32}$$

again F_1, F_2, F_3, and F_4 are given by equations (16) through (19).

The mode conversion programs, as they are now programmed, require that the height variable "d" be at the ground so that in equations (26) through (32), $z = d = 0$.

The function f of equation (25), which is the ratio e_y to h_y at the ground is computed from the T's of equations (26) through (29) as:

$$f = \frac{T_3}{T_1} \qquad \text{or} \qquad f = \frac{T_2}{T_3 \cdot T_4} \tag{33}$$

Define the following terms:

$$\tau_1 = D_{11}\, T_1 \;,\quad \tau_2 = D_{22}\, T_2 \;,\quad \tau_3 = D_{12}\, T_3 . \tag{34}$$

In terms of the above quantities the excitation tensor elements are given as:

$$\begin{array}{ll} & \text{Field Component} \rightarrow \\ & \begin{array}{ccc} \quad E_z \quad & \quad E_x \quad & \quad E_y \quad \end{array} \qquad \text{Exciter}\downarrow \\ \lambda = (\lambda_{ij}) = & \left(\begin{array}{c|c|c} \tau_1 S^2 & \tau_1 S & -\tau_3 S/f \\ \hline -\tau_1 S & -\tau_1 & \tau_3/f \\ \hline -\tau_3 T_4 S/f & -\tau_3 T_4/f & \tau_2/f^2 \end{array} \right) \begin{array}{l} \text{Vertical} \\ \text{End-on} \\ \text{Broadside} \end{array} \end{array} \tag{35}$$

The columns relate to excitation of the electric field components E_z, E_x and E_y and the rows apply to excitation by a vertical dipole (λ_V), a horizontal dipole end-on (λ_E) and a horizontal dipole broadside (λ_B). Recall the geometry of the situation is such that z is taken positive into the ionosphere, that positive x is the direction of propagation and that y is normal to the plane of propagation.

Both the modal excitation factor and the modal height gain functions are needed in computing electric field strengths. The excitation factors of equation (35) must be supplemented with the height gains which are defined as following:

$$f_1(z) = \exp\left(\frac{z-d}{a}\right) (F_1 h_1(q) + F_2 h_2(q))/(F_1 h_1(q_o) + F_2 h_2(q_o)) \qquad (36)$$

$$f_2(z) = \frac{1}{ik} \frac{df_1}{dz} \qquad (37)$$

$$f_3(z) = (F_3 h_1(q) + F_4 h_2(q))f/(F_3 h_1(q_o) + F_4 h_2(q_o)) \qquad (38)$$

where f_1 is the height gain for the vertical electric field E_z, f_2 is the height gain for the horizontal electric field component E_x and f_3 is for the electric field component E_y which is normal to the plane of propagation.

In terms of the excitation factors, height gains and generalized mode conversion coefficients, the electric field components E^p in the p-th slab may be written, as a function of receiver range (ρ), as follows:

$$E_n^{NTR} = \frac{Q}{[\sin(x/a)]^{1/2}} \sum_k (\lambda_{1nk}^{NTR} f_{1k}^{NTR}(z_T) \cos\gamma + \lambda_{2nk}^{NTR} f_{2k}^{NTR}(z_T) \sin\gamma \cos\phi$$

$$+ \lambda_{3nk}^{NTR} f_{3k}^{NTR}(z_T) \sin\gamma \sin\phi) f_{nk}^{NTR}(z_R)\, e^{-iK}(s_k^{NTR} - 1)\rho \; ; \qquad (39)$$

$$p = NTR$$

$$E_n^p = \frac{Q}{[\sin(x/a)]^{1/2}} \sum_j \sum_k (\lambda_{1nk}^{NTR} f_{1k}^{NTR}(z_T) \cos\gamma + \lambda_{2nk}^{NTR} f_{2k}^{NTR}(z_T) \sin\gamma \cos\phi$$

$$+ \lambda_{3nk}^{NTR} f_{3k}^{NTR}(z_T) \sin\gamma \sin\phi)\,(\delta_{1n} + (1 - \delta_{1n})\, s_k^{NTR}/s_j^p) f_{nj}^p(z_R) \cdot \left(a_{jk}^p \frac{S_j^p}{S_k^{NTR}}\right)$$

$$\cdot\, e^{-iK(S_k^{NTR} x_{NTR+1} + s_j^p (\rho - x_p) - \rho)} \quad ; \qquad p \neq NTR \qquad (40)$$

The receiver altitude is z_R and the transmitter altitude z_T. The final k subscript on the λ's and f's denotes mode indices whereas the index n takes on the values 1, 2 and 3. Consistent with the previous definition $n = 1 \rightarrow E_z$, $n = 2 \rightarrow E_x$ and $n = 3 \rightarrow E_y$. Also, the notation "NTR" refers to the transmitter slab. The constant Q is

$$Q = 0.03248k/\sqrt{F} \qquad (41)$$

with the free space wavenumber, k, in inverse km and F the frequency in kHz. The symbol δ_{ij} represents the Kronecker delta. That is

$$\delta_{ij} = 1 \qquad i = j \qquad (42)$$

$$\delta_{ij} = 0 \qquad i \neq j$$

The angles γ and ϕ determine the orientation of the electric dipole source relative to the x, y, z coordinate system as shown in Figure 1. When executing the GRNDMC program, only the vertical E_z field is computed, the transmitter and receiver heights are both zero and $\gamma = \phi = 0$. In both GRNDMC and ARBNMC field strength amplitude is expressed in dB above a microvolt per meter for a one kilowatt radiator and phase in degrees relative to free space.

IV. DESCRIPTION OF PROGRAM EXECUTION

A. General Comments

To handle horizontal inhomogeneities, the ionosphere is divided into a series of vertical slabs, as described in section III. These slabs are labeled 1, 2, . . . , M as shown in Figure 2 and the boundaries between the slabs have coordinates X_2, X_3, . . . , X_M. For each slab and for each mode the ground eigenangle (Θ') and the T_j's defined by Eqs. (26) through (29) must be provided. Note that the transmitter slab is denoted as "NTR".

Several variables which are functions of the earth's magnetic field or are related to the ground conditions must first be identified. The geomagnetic field is specified by three variables. "AZIM" is the clockwise angle between magnetic north and the horizontal propagation direction in degrees east of north. "CODIP" is the complement of the magnetic dip angle in degrees. The magnetic equator is specified by "CODIP = 90". "MAGFLD" is the magnetic field intensity in webers per square meter. The ground conditions are specified by two variables. "SIGMA" is the conductivity in mhos per meter and "EPSR" is the relative dielectric constant. The mode finding programs, references 4 or 5, punch the values of these variables on the first output card of each "slab". This card is denoted as the RFACMSET card. The variables on this card are identified as:

R: The slab reference distance in megameters.

F: The propagation frequency, in kHz, "FREQ".

A: The geomagnetic azimuth in degrees, "AZIM".

C: The geomagnetic codip in degrees, "CODIP".

M: The magnitude of the geomagnetic field in weber/square meter, "MAGFLD".

S: The earth's conductivity in mhos/meter, "SIGMA".

E: The relative dielectric constant of the earth, "EPSR".

T: The height of the top of the slab, "TOPHT".

B. Description of Input

All input to the mode conversion program is given in a data deck on the standard input unit. Listings of sample input showing data deck setup are given in example I and example II. Example I illustrates the input cards for the option IPLTOP = 1, while example II shows the input for the option IPLTOP = 2.

There are two parts to the input. The first part is read in by means of a Fortran NAMELIST input format. The first card of each set of input must contain a blank in column 1 and &DATUM in columns 2-7. This is followed by at least one blank and then data items separated by commas. The data items have the following forms: (all cards must have a blank in column 1)

variable name = constant,

or

array name = set of constants, (all separated by commas),

The second part of the input follows the NAMELIST input. The first input for this part is an identification card. It has up to 40 columns of alphanumeric information and follows the control card, "DATA". The information on the identification card is used to label output plots. Following the identification card a series of punched cards (obtained from the programs described in references 4 or 5 with NPUNCH = 1) is input for each slab of the modeled earth-ionosphere waveguide. The first card is denoted as the RFACMSET and gives the value for R, FREQ, AZIM, CODIP, MAGFLD, SIGMA, EPSR and TOPHT. Next there are two cards per mode. The first of these contains the complex eigenangle at the ground (i.e., Θ'_r and Θ'_i) and values for the variables T_1 (Real), T_1 (Imaginary), T_2 (Real) and T_2 (Imaginary). See equations (26) and (27). The second card contains the eigenangles at the ground (Θ'_r and Θ'_i) (duplicate input) and T_3 (Real), T_3 (Imaginary), T_4 (Real) and T_4 (Imaginary). See equations (28) and (29). If the number of modes in any given slab is "NRMODE", there will be 2*NRMODE cards for each slab. The 2*NRMODE cards for slab No. 2 follow those for slab No. 1 and so on up to slab number M. Although ordering of modes is not critical, they are ordered according to their real parts. (The mode with the largest real part is called mode 1.)

The following variables and arrays may be specified in the NAMELIST input:

IPLTOP - Plotting option flag. If IPLTOP = 1, two plots (field amplitude in dB above a μv/m for 1 kw radiated power versus transmitter -terminator distance for two receiver positions) are produced for each set of input. If IPLTOP = 2, a plot (field amplitude in dB above a μv/m for 1 kw versus distance from transmitter) is produced.

XVAL - The numerical values (in km) of the X's (see Figure 2) which are the horizontal positions of the boundaries between adjacent slabs. Note that XVAL can be negative and that it is dimensioned for 50. Figure 2 illustrates that the XVAL distances are taken relative to the transmitter. The slab number is identified by ISLAB and a particular slab is identified by XVAL(ISLAB). That is, XVAL(3) = X_3. Note that the terminator line is taken to be the boundary XVAL(2).

RCDOPT - Option to use the RFACMSET-card values (i.e., R) for XVAL(ISLAB) values. If RCDOPT is set equal to one and IPLTOP is set equal to two, then the values used for XVAL(ISLAB) are taken from the RFACMSET card rather than from NAMELIST.

RHOMAX - Maximum horizontal distance in km at which field strengths are desired.

RHOMIN - Minimum horizontal distance in km at which field strengths are desired.

DELRHO - Horizontal increment in km for which successive field strengths are computed.

NTMAX - Number of times the transmitter - terminator separation is incremented. (NTMAX = 1 for IPLTOP = 2.)

DELTAX - Distance in km by which transmitter - terminator separation is incremented. (DELTAX = 0.0 for IPLTOP = 2.)

GAMMA or INCL - Dipole orientation angle relative to z axis (see Figure 1). Note that GAMMA is dimensioned for 4.

PHI or THETA - Dipole orientation angle relative to X axis (see Figure 1). Note that PHI is dimensioned for 4.

NRP - Number of GAMMA-PHI pairs up to 4.

TALT - Transmitter altitude in km.

RALT - Receiver altitude in km.

ICOMP - The electric field components to be computed. ICOMP = 1 is E_z, ICOMP = 2 is E_x and ICOMP = 3 is E_y.

ICMPMX - The maximum number of components which will be computed. If equals 1 only E_z. If equals 2 only E_z and E_x. If equals 3, E_z, E_x and E_y will be computed. Note that if only E_x is wanted, ICMPMX still must be set equal to 2. If only E_y is required, ICMPMX still must be set equal to 3.

TOPHT - Height above ground in km above which height gains are discarded. Note that a TOPHT for each slab is required and dimensioned for 50. If the value of TOPHT(ISLAB) is zero then the values of TOPHT used in the internal calculations within the program are taken from the RFACMSET cards.

H - Is the height in km at which the modified refractive index is unity ($n^2 = 1 - 2/a(H - z)$). a is the earth's radius. H is also the height to which the eigenangles are referred.

IH - Option which, when set to one converts the SIN(Θ') to SIN(Θ_H). The values of Θ' are the eigenangles at the ground while the values Θ_H are the eigenangles referenced at the height H. The equation is

$$\sin(\Theta_H) = (1 - H/a) \sin(\Theta').$$

This relation is important in computations of the excitation factors.

INTFLG - Printing option flag. INTFLG must be set to 1 if printout of height gain integrals and the "normalized" conversion coefficients are required (i.e., $\underset{\sim}{I}^{p,p}$, $\underset{\sim}{I}^{p,p-1}$ and $\underset{\sim}{\bar{I}}^{p}$ of equation 6).

IPRNTA - Printing option flag. IPRNTA must be set to 1 if printout of the "accumulated" or total mode conversion coefficients is required (i.e., $\underset{\sim}{a}^P$ of equation 7).

NPRINT - Printing option flag. NPRINT equal to 1 gives a brief summary of slab input data including slab number and the number of modes for each slab. Printed out are the values of all the variables contained on the RFACMSET cards. NPRINT = 3 gives the same printed output as for NPRINT = 1, except that the values of the ground eigenangle and the values of the T's of equations (26) through (29) are also given for each slab.

ITXRX - Printing option flag. ITXRX must be set to 1 for debugging purposes.

NAPLOT - Plotting option flag. NAPLOT must be set to 1 if plots of amplitude vs. distance are required.

NPPLOT - Plotting option flag. NPPLOT must be set to 1 if plots of phase vs. distance are required.

SIZEX - Length of x-axis in inches.

SIZEY - Length of y-axis in inches (for amplitude).

XMIN - The value (in km) of the x-coordinate at the beginning of the x-axis.

YMIN - The value (in dB) of the y-coordinate at the beginning of the y-axis.

XINC - The change in the x-coordinate value (in km) between successive labeled tic marks.

YINC - The change in the y-coordinate value (in dB) between successive labeled tic marks.

XTIC - The distance (in inches) between tic marks along the x-axis.

YTIC - The distance (in inches) between tic marks along the y-axis (for amplitude).

NTICX - The repeat cycle for placing coordinate values at tic marks on the x-axis.

NTICY - The repeat cycle for placing coordinate values at tic marks on the y-axis (for amplitude).

SIZEP - Length of y-axis in inches (for phase).

PHSMIN - The value (in degrees) of the y-coordinate at the beginning of the y-axis.

PHSINC - The change in the y-coordinate value (in degrees) between successive labeled tic marks.

PTIC - The distance (in inches) between tic marks along the y-axis (for phase).

NTICP - The repeat cycle for placing coordinate values at tic marks on the y-axis (for phase).

FACT - The ratio of the desired plot size to the normal plot size. For example, if FACT = 2.0, all subsequent pen movements will be twice their normal size. When FACT is reset to 1.0, all plotting is normal size.

Note: For NTICX, NTICY and NTICP:

= 1 - causes values to be placed at every tic mark

= 2 - causes values to be placed at every second tic mark, etc.

= 0 - suppresses all coordinate values

The end of the NAMELIST input is signaled by &END.

Initial values of the NAMELIST variables are presented in Table 1.

TABLE 1

NAMELIST VARIABLES AND INITIAL VALUES

NAME	VALUE	UNITS	NAME	VALUE	UNITS
*ICOMP	1	--	SIZEX	10.0	inches
*ICMPMX	3	--	SIZEY	8.0	inches
LTXRX	0	--	XMIN	0.0	km
INTFLG	0	--	YMIN	0.0	db
IPRNTA	0	--	XINC	1000.0	km
IPLTOP	0	--	YINC	10.0	db
NRP	1	--	XTIC	1.0	inches
NTMAX	1	--	YTIC	1.0	inches
NPRINT	1	--	NTICX	1	--
RHOMAX	0.0	--	NTICY	1	--
RHOMIN	0.0	--	RCDOPT	0	--
DELRHO	0.0	--	IH	1	--
DELTAX	0.0	--	H	50.0	km
*GAMMA	4*0.0	degrees	*RALT	0.0	km
*PHI	4*0.0	degrees	*TALT	0.0	km
*INCL	4*0.0	degrees	SIZEP	8.0	inches
*THETA	4*0.0	degrees	PHSMIN	0.0	degrees
XVAL	50*0.0	km	PHSINC	90.0	degrees
TOPHT	50*0.0	km	PTIC	2.0	inches
NAPLOT	1	--	NTICP	1	--
NPPLOT	0	--			
FACT	1.0	--			

Note: Variables denoted with asterisk (*) apply only to the ARBNMC program and not to the GRNDMC program.

C. Special Rules

Some special rules must be applied to the selection of some of the NAMELIST variables.

(1) Consider the following relationship as related to plotting:

ΔX - increment of x-scale in km/inch

$$\Delta X = \frac{XINC}{(NTICX) \cdot (XTIC)} \left\{\frac{km}{inch}\right\}$$

Example (a). Given: XINC = 2000 km

NTICX = 2

XTIC = 1 inch

$$\Delta X = \frac{2000 \text{ km}}{2 \cdot 1 \text{ inch}} = 1000.0 \text{ km/inch}$$

Also:

ΔY - increment of y-scale in db/inch

$$\Delta Y = \frac{YINC}{(NTICY)(YTIC)} \left\{\frac{db}{inch}\right\}$$

Example (b). Given: YINC = 30 dB

NTICY = 2

YTIC = 0.5 inch

$$\Delta Y = \frac{30 \text{ dB}}{2 \cdot (0.5) \text{ inch}} = 30 \text{ dB/inch}$$

Further:

Example (c). Given: XINC = 1000 km

NTICX = 1

XTIC = 1 inch

$$\Delta X = \frac{1000 \text{ km}}{(1) \cdot (1) \text{ inch}} = 1000 \text{ km/inch}$$

Note (1):

Example (c) shows that, if values of the axis are to be labeled at every tic mark, then NTICX = 1. Also, if XTIC is 1 inch, then ΔX = XINC. Therefore, in this case XINC indicates the value of the increment of the x-scale in km/inch. In the same manner, YINC would indicate the value of the increment of the y-scale in dB/inch.

(2) Consider the following relationships:

$$\text{SIZEX} = \frac{\text{XMAX} - \text{XMIN}}{\Delta X}$$

$$\text{NTMAX} = \frac{\text{XMAX} - \text{XMIN}}{\text{DELTAX}} + 1$$

Note (2):

XMAX is not a NAMELIST variable but it must be considered when deciding on the values for the other NAMELIST variables.

Example (d). Given: DELTAX = 200.0 km

ΔX = 1000.0 km/inch

XMIN = -2000 km

"XMAX" = 5000 km

SIZEX = ? inches

NTMAX = ? inches

$$SIZEX = \frac{XMAX - XMIN}{\Delta X}$$

$$SIZEX = \frac{5000. -(-2000)}{1000.0} = 7 \text{ inches}$$

$$NTMAX = \frac{XMAX - XMIN}{DELTAX} + 1$$

$$NTMAX = \frac{5000. -(-2000)}{200} + 1 = 36$$

(3) The following rules must be used when picking values of certain NAMELIST variables:

For "IPLTOP" = 1, Set:
XVAL(1) = -9999.9
XVAL(2) = XMIN

For "IPLTOP" = 2, Set:
XVAL(1) = 0.0
XMIN = 0.0
NTMAX = 1
DELTAX = 0.0
RHOMIN = DELRHO
RHOMAX $\leq$ "XMAX"

(4) XVAL distances are taken relative to the transmitter (NTR). The terminator line is XVAL(2).

(5) The maximum value possible for SIZEY or SIZEP is 8 inches.

(6) For the option IPLTOP equal to 1, the criteria for modeling "sunset" or "sunrise" at the receiver are shown in figure 4a through d. Figure 4a, for sunset illustrates that the daytime mode constants (smaller value of TOPHT) are assumed for slab No. 1, while the nighttime mode constants are assumed for

slab No. 4. The mode conversion programs allow for incrementing the XVAL distances (which are distances relative to the transmitter) by the distance DELTAX. Figure 4b shows the resulting mode sum value in dB as a function of the distance between the terminator line (XVAL(2)) and the transmitter. Figures 4c and 4d illustrate the input and resulting mode sum curves for the "sunrise" condition. In this case the mode constants for nighttime are assumed for slab No. 1 while the daytime mode constants are assumed for slab 4.

(7) The mode conversion programs, as they are now formulated, require that the height "d" of equations 1, 2, 3 and 25 through 32 be set to the ground level (i.e., d = 0). This requires that when the T's of equations 26 through 32 are obtained from the program described in reference 4, the variable "D" in that program must be set to zero. Also, if the T's are obtained from the program described in reference 5, the variable "GRDFLG" in that program must be set to 1.

(8) The maximum number of data points (i.e., distances) for which fields can be computed is 402.

(9) The maximum number of allowable modes is 20.

(10) The maximum number of allowable slabs is 50. This value may be increased by increasing the dimensions of the variables TOPHT and XVAL.

D. Program Layout

The subroutines used in the GRNDMC and the ARBNMC mode conversion computer programs are shown in Table II.

TABLE II

Program Subroutines

GRNDMC	ARBNMC
MAIN	MAIN
CLINEQ	CLINEQ
AXISM	AXISM
MAGANG	MAGANG
MDHNKL	MDHNKL
MCSTEP	MCSTEP
HTIMTL	HTIMTL
*MCFLD (for GRNDMC)	*MCFLD (for ARBNMC)
MCFLD2	ACCUMA
*MCPLTS (for GRNDMC)	*MCPLTS (for ARBNMC)
MCPLT2	HTGAIN
	CURVE

The flow of the programs GRNDMC and ARBNMC is shown in Figure 5. Note that GRNDMC utilizes two temporary disc files and that ARBNMC utilizes four temporary disc files.

The subroutines denoted with the asterisk indicate that these subroutines are not identical in the two programs.

SUBROUTINE HTGAIN (Z, H, HFLAG)

Z is dimensioned for 2. Z(1) is set equal to the transmitter height TALT and Z(2) is set equal to the receiver height RALT. The height gain functions f_1, f_2 and f_3 defined by Eqs. (36), (37) and (38) respectively are computed for the transmitter and receiver heights. H is the height where the modified index of refraction is one. IH = 0 indicates H = 0 and IH = 1 indicates $H \neq 0$ in the subroutine calculations.

SUBROUTINE HTINTL (IFLG, P, INTFLG)

HTINTL calculates the height integrals defined by Eq. (6). NORM ($I^{p,p}$) is an array of 20 by 20 which contains all combinations of modal integrals for the slab p. Also CAPI ($I^{p,p-1}$) is an array of 20 by 20 which contains all combinations of modal height gain integrals for the slab p and the previous slab p-1. IFLG is a control flag set to zero in MAIN if the slab p equals one. It is set to 1 if p is not equal to one. INTFLG is a printing option flag. It must be set to 1 if printout of NORM, CAPI and INORM ($\overline{I}^{\,p}$) is desired. Note from equation 6 that the array INORM is the normalized conversion coefficient.

SUBROUTINE MDHNKL (Z, H1, H2, H1PRME, H2PRME)

MDHNKL calculates for argument Z two independent solutions (H1 and H2) and their derivatives (H1PRME and H2PRME) of Stokes' equation by methods described in reference 9.

SUBROUTINE MAGANG (ARG, MAG, ANGLE)

MAGANG converts complex number ARG to polar form with ANGLE in degrees.

SUBROUTINE CLINEQ (A, B, X, N, NDIM, IFLAG, ERR)

CLINEQ computes the solution of simultaneous linear equations with complex coefficients. That is, it solves the matrix equation

$$A * X = B$$

for the vector X of length N, given the matrix A of size N by N and the vector B of length N by Crout's L-U decomposition. The A is destroyed by CLINEQ, NDIM is an integer variable which must be greater than or equal to N. IFLAG is an integer variable normally set to zero. Setting IFLAG = 1 bypasses the L-U decomposition of A when solutions are required for different B's. ERR is a real variable computed by CLINEQ which indicates the relative errors in the computed solution vector X.

SUBROUTINE MCSTEP (M)

MCSTEP calls for CLINEQ and provides as its output the mode conversion coefficients for the slabs NTR, NTR + 1 . . ., M for all values of NTR consistent with the input data. The mode conversion coefficients defined by equation 7 are printed out under the "A = TOTAL CONVERSION COEFFICIENTS".

SUBROUTINE AXISM

AXISM draws and labels the axes for the output plots.

SUBROUTINE CURVE (for ARBNMC)

CURVE plots the data points on the output plots.

SUBROUTINE MCFLD (for GRNDMC)

MCFLD called from MAIN if IPLTOP = 1 computes the vertical electric field at the ground produced by a ground based vertical electric dipole at RHOMIN and RHOMAX for transmitter-terminator distances ranging between XVAL (2) and NTMAX*DELTAX + XVAL (2) at intervals of DELTAX, using equations (39) and (40) with $\gamma = 0^o$, $\phi = 0^o$, $Z_T = 0$, $Z_R = 0$ and $f_1 = f_2 = f_3 = 1$.

SUBROUTINE MCFLD2 (for GRNDMC)

MCFLD2 called from MAIN if IPLTOP = 2 computes the vertical electric field at the ground produced by a ground based vertical electric dipole from RHOMIN to RHOMAX at DELRHO intervals using equations (39) and (40) for a fixed horizontal inhomogeneity. Again, $\gamma = 0^o$, $\phi = 0^o$, $Z_T = Z_R = 0$ and $f_1 = f_2 = f_3 = 1$.

SUBROUTINE MCPLTS (ITYPE) (for GRNDMC)

MCPLTS generates two plots (field amplitude in dB above a μv/m for 1 kw radiated power (or phase in degrees) versus transmitter-terminator distance for two receiver positions) each time it is called from MCFLD. ITYPE = 1 gives amplitude plots. ITYPE = 2 gives phase plots.

SUBROUTINE MCPLT2 (ITYPE) (for GRNDMC)

MCPLT2 generates one plot (field amplitude in dB above a μv/m for 1 kw radiated power (or phase in degrees) versus distance from transmitter) each time it is called from MCFLD2. ITYPE = 1 gives amplitude plots. ITYPE = 2 gives phase plots.

SUBROUTINE ACCUMA (for ARBNMC)

ACCUMA is the chief control routine of ARBNMC. The routine sets up the accumulated values of the "total" or accumulated conversion coefficient as a function of slab position.

SUBROUTINE MCFLD (for ARBNMC)

MCFLD when called from MAIN with IPLTOP = 1 computes the field components E_n^p defined by Eqs. (39) and (40) for transmitter height Z_T (TALT) and receiver height Z_R (RALT) for as many as four (GAMMA, PHI) pairs. GAMMA and PHI describe the orientation of the electric dipole source. Calculations are made for ranges RHOMIN and RHOMAX for distances between the transmitter and the start of the horizontal inhomogeneity ranging between XVAL (2) and NTMAX*DELTAX + XVAL (2) at intervals of DELTAX using Eqs. (39) and (40). Field amplitude outputs are in dB above a μv/m for 1 kw radiated power and phase angles are in degrees relative to free space phase.

MCFLD when called from MAIN with IPLTOP = 2 computes the field components E_n^p defined by Eqs. (39) and (40) for transmitter height Z_T (TALT) and receiver height Z_R (RALT) for as many as four (GAMMA, PHI) pairs. Calculations are made for transmitter-receiver distances ranging from RHOMIN to RHOMAX at DELRHO intervals using Eqs. (39) and (40) for a fixed horizontal inhomogeneity. Field amplitude outputs are dB above a μv/m for 1 kw radiated power and phase angles are in degrees relative to free space phase.

SUBROUTINE MCPLTS (ITYPE) (for ARBNMC)

MCPLTS, for IPLTOP = 1, generates six plots (three field component amplitudes in dB above a μv/m for 1 kw radiated power (or phase in degrees) versus distance between transmitter and start of the horizontal inhomogeneity for two receiver ranges). As many as four (GAMMA, PHI) pairs are possible so that each plot can contain as many as four curves.

MCPLTS, for IPLTOP = 2, generates three plots (three field component amplitudes in dB above a μv/m for 1 kw radiated power (or phase in degrees) versus transmitter receiver distance for a single location of the horizontal inhomogeneity). As many as four (GAMMA, PHI) pairs are possible so that each plot can contain as many as four curves.

ITYPE = 1 gives amplitude plots. ITYPE = 2 gives phase plots.

E. Description of Output

Sample output from program ARBNMC is shown in example III. This output is obtained from the input shown in example I. The output listing begins with an abbreviated listing of the NAMELIST input variables. Note that the IPLTOP = 2 option is requested. This is followed by printout of the control card "DATA" and the identification card, "PRESTON U.K. TO SONDRESTROM". Next comes the printout of the NPRINT = 3 option giving slab number, the RFACMSET card values and then a listing of Θ' angles and T's for all slabs and modes. The Θ' angles are the eigenangles at the ground while the T's are the complex quantities given by equations (26) through (29).

The principal output of the mode conversion program then follows. Since INTFLG was set equal to one, values of certain parameters are printed out for each slab, P. These quantities are INORM (J,K) (i.e., $\bar{I}^{P}_{jk}$ of equation 6), which are the normalized conversion coefficients of mode K in slab P-1 to mode J in slab P; NORM (I,J) (i.e., $I^{p,p}_{ij}$ of equation 13), which are values of the integral between height gains of the I and J modes in slab P; and CAPI (I,K) (i.e., $I^{p,p-1}_{ik}$ of equation 13), which are values of the integrals between height gains for mode K in slab P-1 and mode I in slab P. Also, since IPRNTA was set equal to one the "total (or accumulative)" mode conversion coefficients a^{P}_{jk} of equation 7 are printed out. The tabulation represents the conversion from mode K in the transmitter slab to mode J in slab P.

Finally, the mode sum values for the vertical electric field (E_z) at transmitter height of 0.0 km and receiver height of 6.0 km are listed in dB above a microvolt per meter for a 1 kilowatt radiator as well as the phase in degrees referenced to free space propagation. In this example mode sums are shown for receiver locations at a distance (ρ) with ρ varying from 25 km to 4000 km at 25 km intervals. A plot of the computed fields is shown in figure 6 as compared with propagation data described in reference 13.

Example IV illustrates the output obtained from the input of example II. In this case the IPLTOP = 1 option was requested. The first part of the printout shows the NAMELIST values. Because NPRINT was set to one only a brief summary of the input data (i.e., the RFACMSET values) is printed after the "DATA" and identification cards. Also, since neither INTFLG or IPRNTA was set to one, no printout of the height gain integrals or conversion coefficients are printed out. Since IPLTOP was set equal to 1 the sample output shows mode sums for the three electric field components E_z (ICOMP = 1), E_x (ICOMP = 2) and E_y (ICOMP = 3) as a function of transmitter-receiver distance ranging from RHOMIN to RHOMAX at DELRHO intervals. It should be pointed out that *the NAMELIST variable, ICOMP, must be entered in three* separate calls to NAMELIST. The mode sums are listed in dB/μv/m for a one kilowatt radiator and the phases in degrees relative to free space. Because NRP = 4 in the input, there are four GAMMA-PHI pairs (i.e., four antenna orientations) for which the mode sums are computed. Note that TALT = 10 km and RALT = 10 km. Shown in figure 7 (a, b, c, d, e, f) are plots generated by the mode conversion program for this case.

V. REFERENCES

1. Pappert, R. A., and Shockey, L. R. [1975] Effective Ionospheric Height For a Simplified Mode Conversion Model at VLF. Naval Electronics Laboratory Center Interim Report 761.

2. Pappert, R. A. and Shockey, L. R. [1976] Simplified VLF/LF Mode Conversion Program with Allowance for Elevated, Arbitrarily Oriented Electric Dipole Antennas. Naval Electronics Laboratory Center Interim Report 77T, NTIS ADA033412, Springfield, VA.

3. Pappert, R. A. and Shockey, L. R. [1972] Mode Conversion Program for an Inhomogeneous Anisotropic Ionosphere. Naval Electronics Laboratory Center Interim Report 722, NTIS, AD743948, Springfield, VA.

4. Sheddy, C. H., Pappert, R. A., Gough, Y. and Moler, W. F. [1968] A Fortran Program for Mode Constants In An Earth-Ionosphere Waveguide. Naval Electronics Laboratory Center Interim Report 683.

5. Morfitt, D. G. and Shellman, C. H. [1976] MODESRCH, an Improved Computer Program for Obtaining ELF/VLF/LF Mode Constants. Naval Electronics Laboratory Center Interim Report 77T, NTIS, ADA032573, Springfield, VA.

6. Budden, K. G., [1955] The Numerical Solution of Differential Equations Governing Reflexion of Long Radio Waves from the Ionosphere, Proceedings Royal Society (London) A227, pp. 516-537.

7. Sheddy, C. H. [1968] "A General Analytic Solution for Reflection from a Sharply Bounded Anisotropic Ionosphere," Radio Science, V. 3, No. 8, pp. 792-795.

8. Pappert, R. A., E. E. Gossard, and I. J. Rothmuller, [1967], "A Numerical Investigation of Classical Approximations Used in VLF Propagation," Radio Science, V. 2, pp. 387-400.

9. Staff of the Computation Laboratory at Cambridge, Massachusetts, [1945] Tables of the Modified Hankel Functions as Order One-Third and of their Derivatives. (Harvard Univ. Press, Cambridge, MA).

10. Pappert, R. A. and Shockey, L. R. [1974] A Simplified Mode Conversion Program for VLF Propagation In the Earth-Ionosphere Waveguide. Naval Electronics Laboratory Center Interim Report 751.

11. Pappert, R. A. and Smith, R. R. [1972] Orthogonality of VLF Height Gains in the Earth Ionosphere Waveguide. Radio Science, V. 7, pp. 275-278.

12. Wait, J. R. and Spies, K. P. []965] "Influence of Finite Ground Conductivity on the Propagation of VLF Radio Waves," Radio Science, NBS Journ. of Research, 69D, pp. 1359-1373.

13. Burgess, B. R. [1972], Royal Aircraft Establishment, Farnborough, England, letter to Commanding Officer, Naval Ocean Systems Center, San Diego, CA.

VI. FIGURES

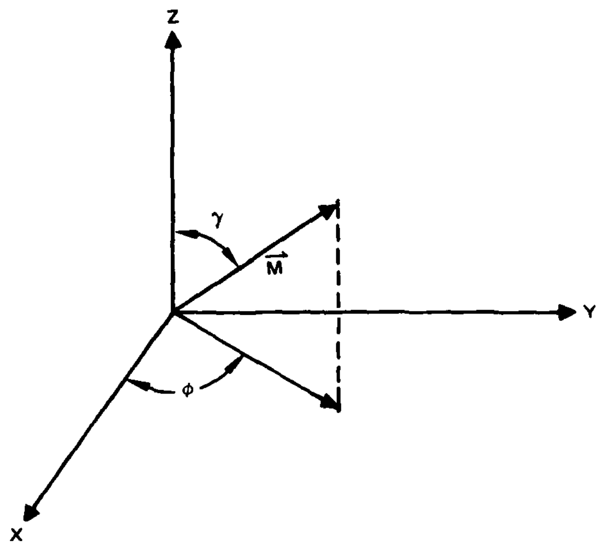


Figure 1. Dipole $\vec{M}$ orientation within the waveguide where γ is the inclination and ϕ the azimuthal orientation.

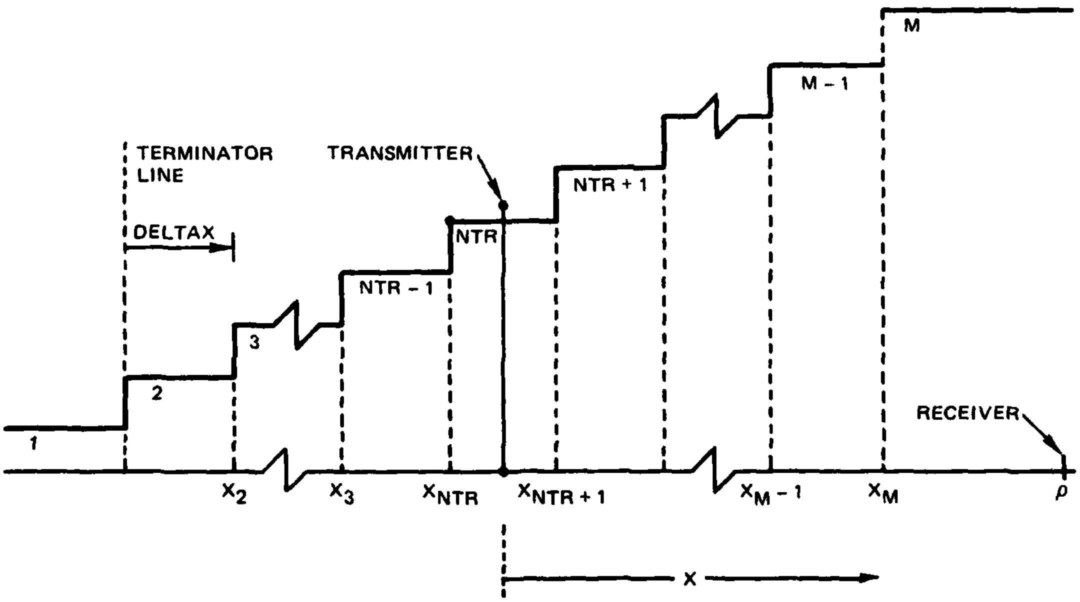


Figure 2. Mode conversion model.

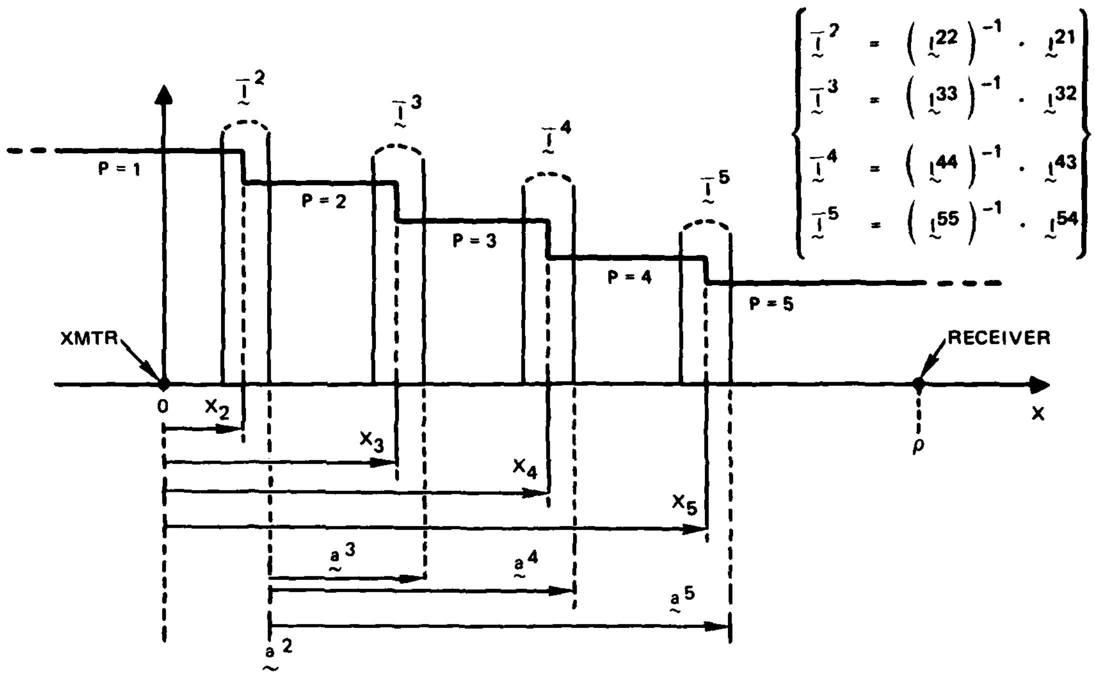
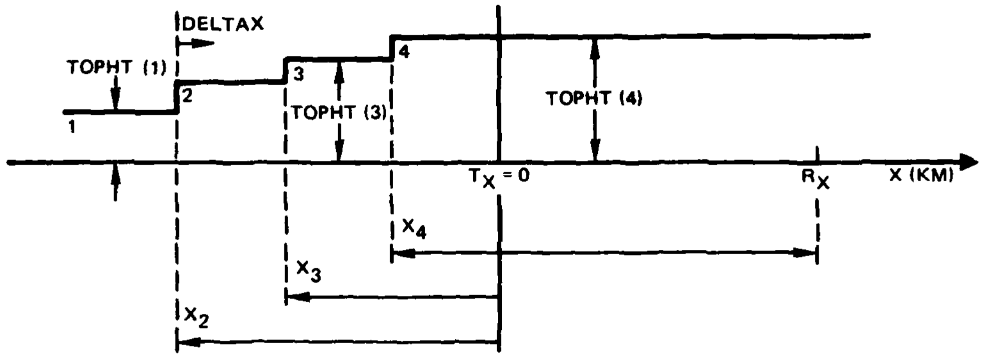
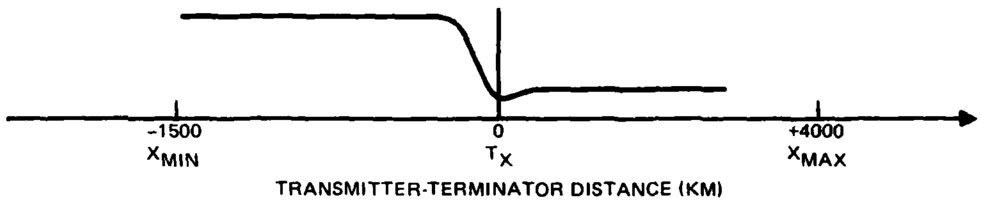


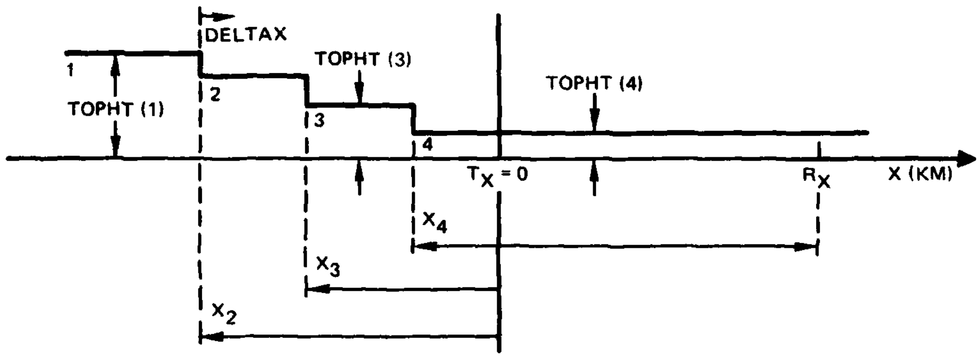
Figure 3. Identification of the terms: "accumulative (or total)" conversion coefficient, $\underset{\sim}{a}^P$ and "normalized" conversion coefficient, $\underset{\sim}{\bar{I}}^P$.



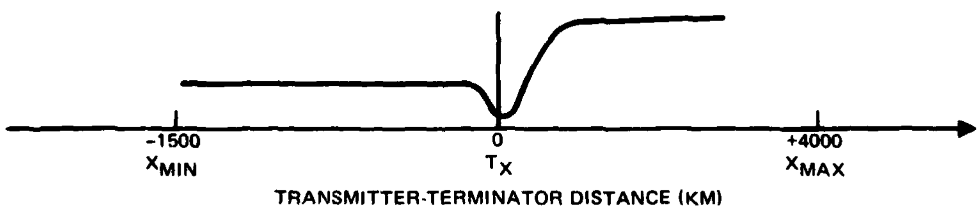
(a) SUNSET INPUT GEOMETRY FOR MOVING TERMINATOR.



(b) RESULTING FIELD STRENGTH AMPLITUDE PLOT FOR SUNSET.



(c) SUNRISE INPUT GEOMETRY FOR MOVING TERMINATOR.



(d) RESULTING FIELD STRENGTH AMPLITUDE PLOT FOR SUNRISE.

Figure 4. SUNRISE-SUNSET geometry.

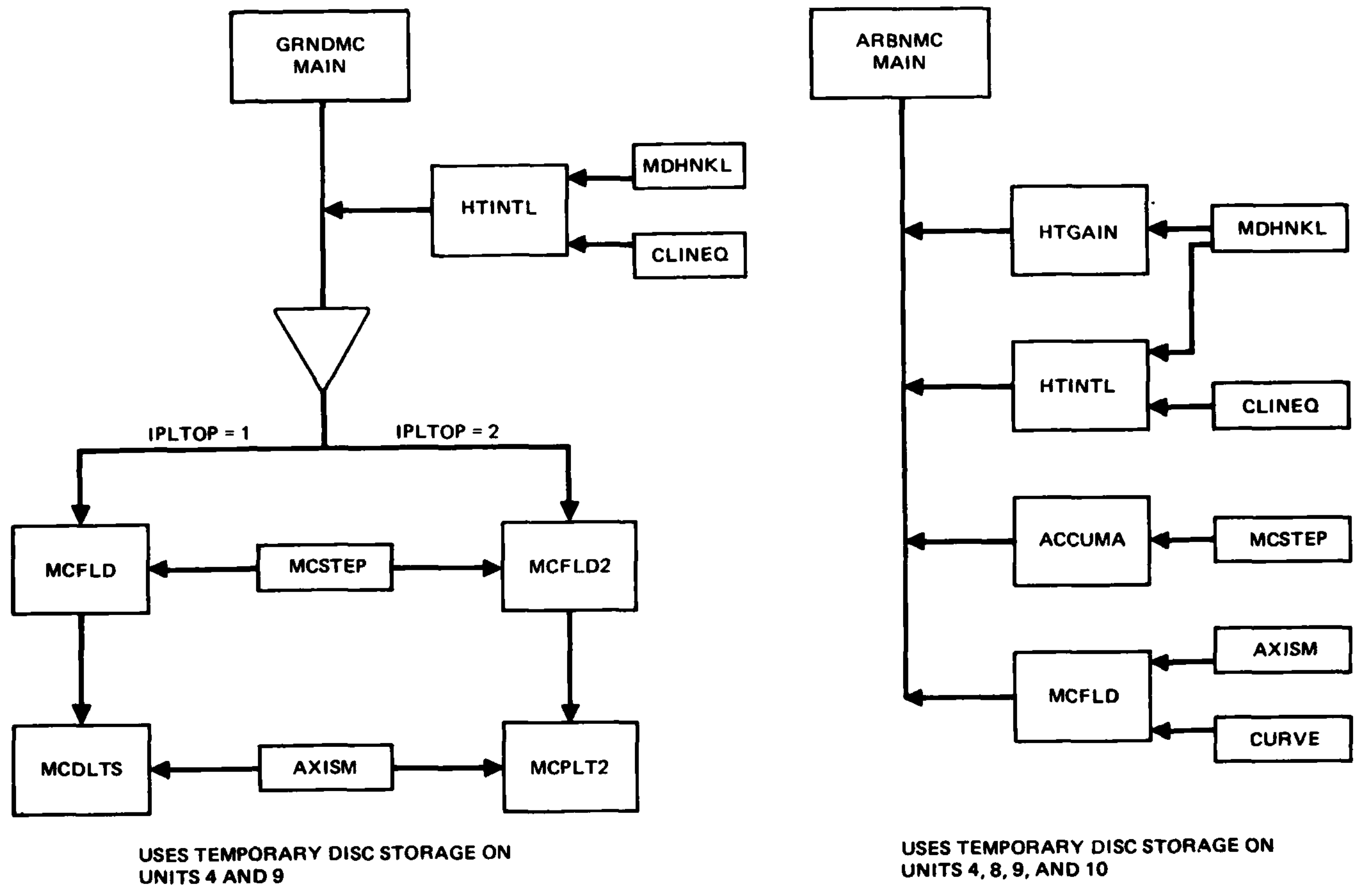


Figure 5,a. Program Flow.

SUBROUTINE "MAIN" FOR PROGRAMS
"ARBNMC" AND "GRNDMC"

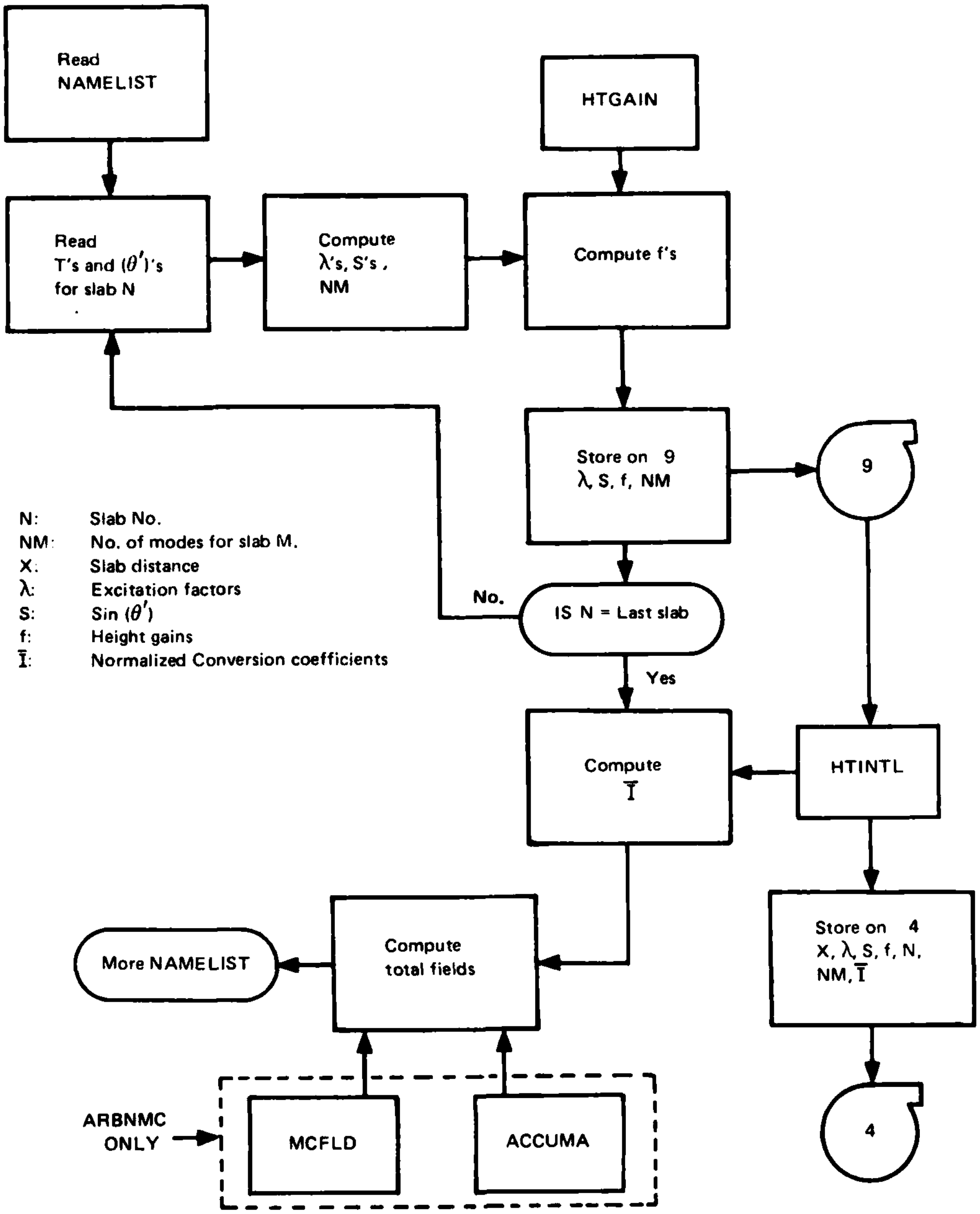


Figure 5, b. Program flow

SUBROUTINE "ACCUMA" OF "ARBNMC"

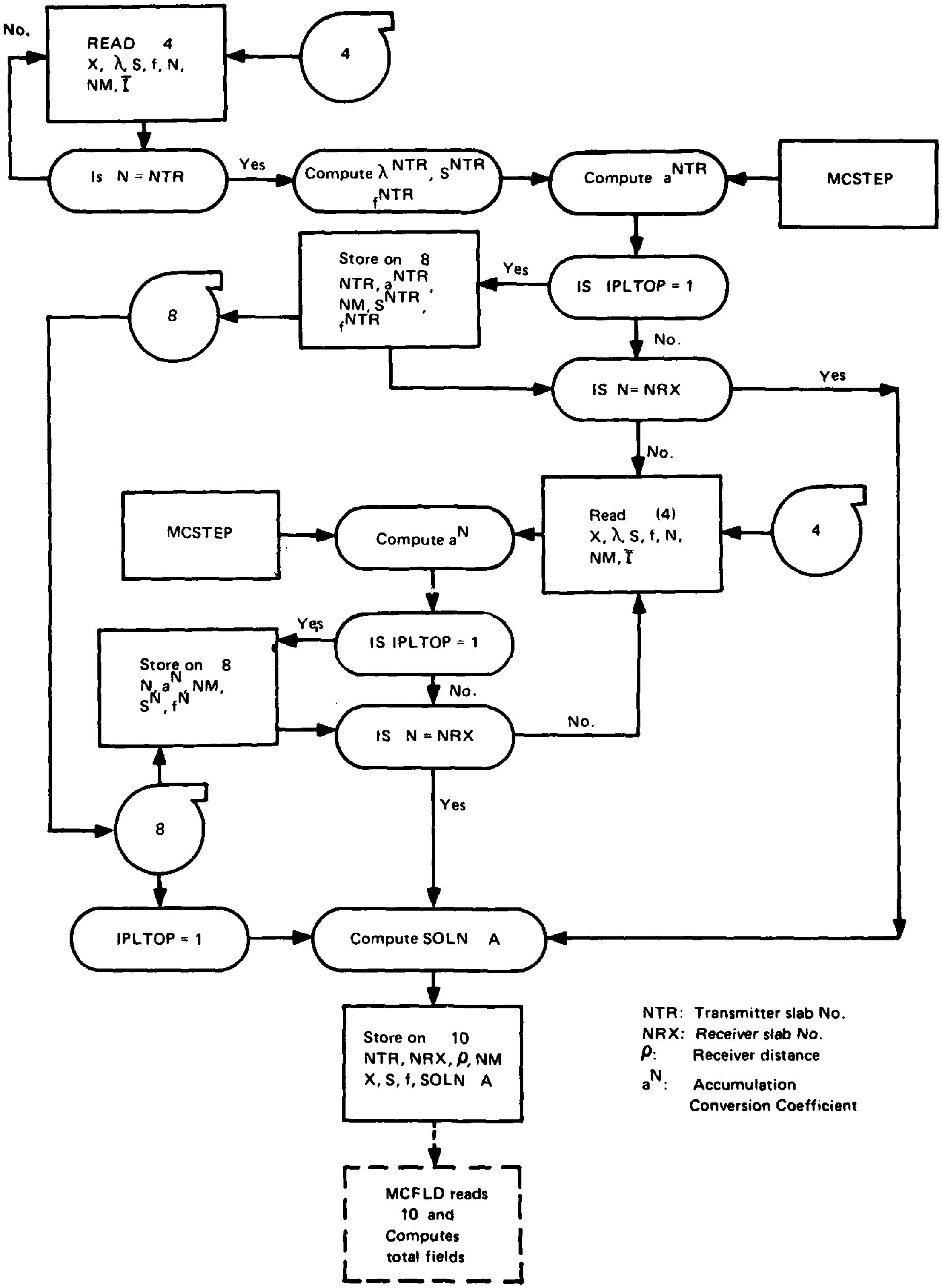


Figure 5, c. Program flow.

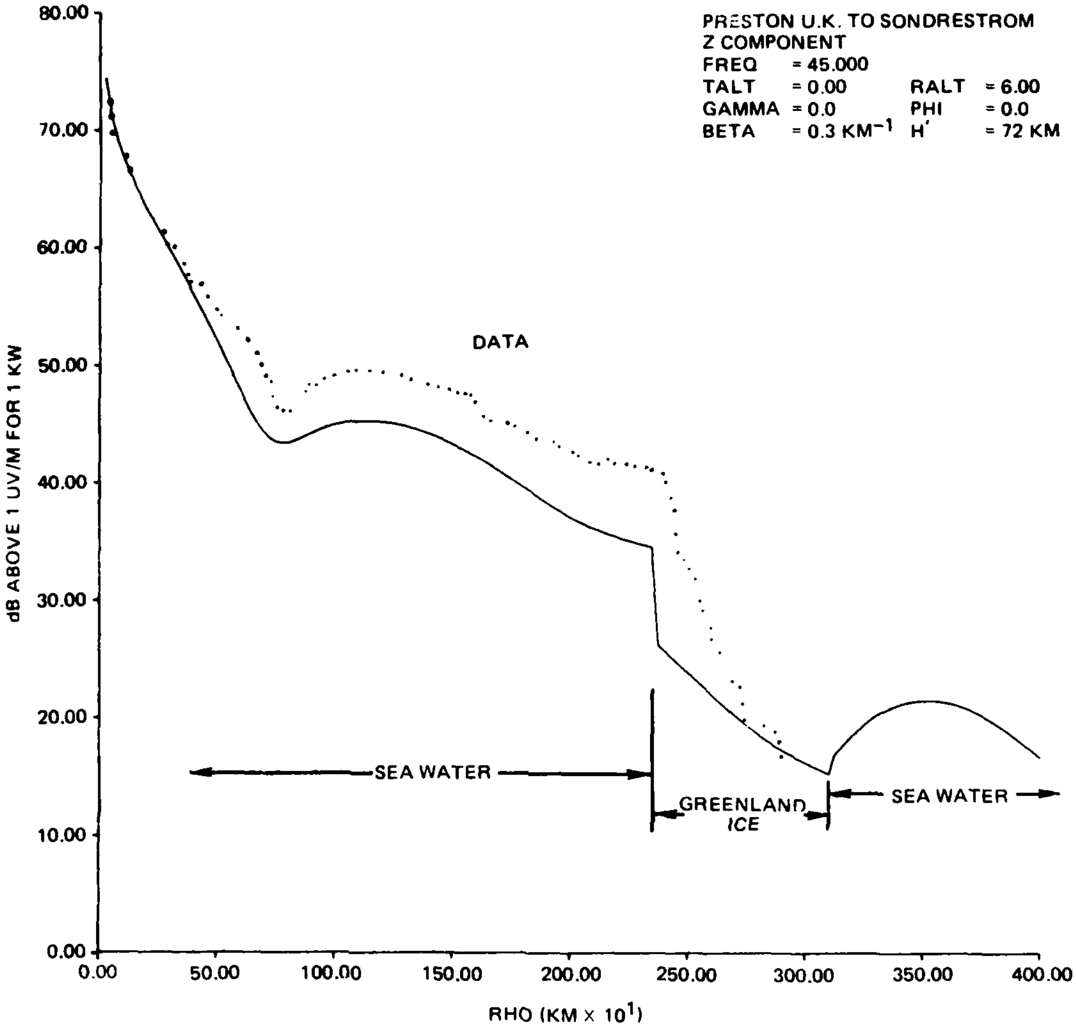


Figure 6. Daytime high latitude propagation across the Greenland ice cap (IPLTOP = 2).

a.

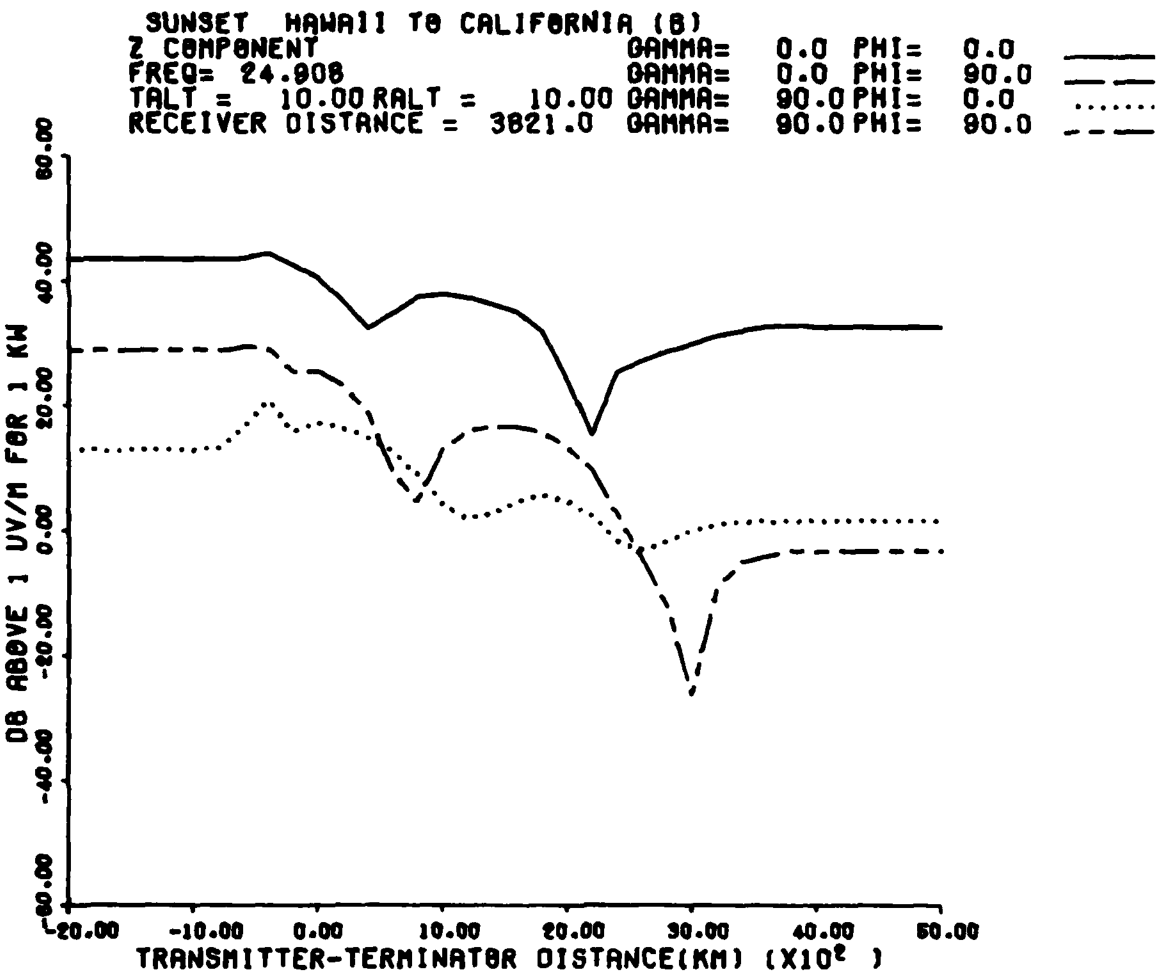


Figure 7. Propagation through the sunset terminator. (IPLTOP = 1).

b.

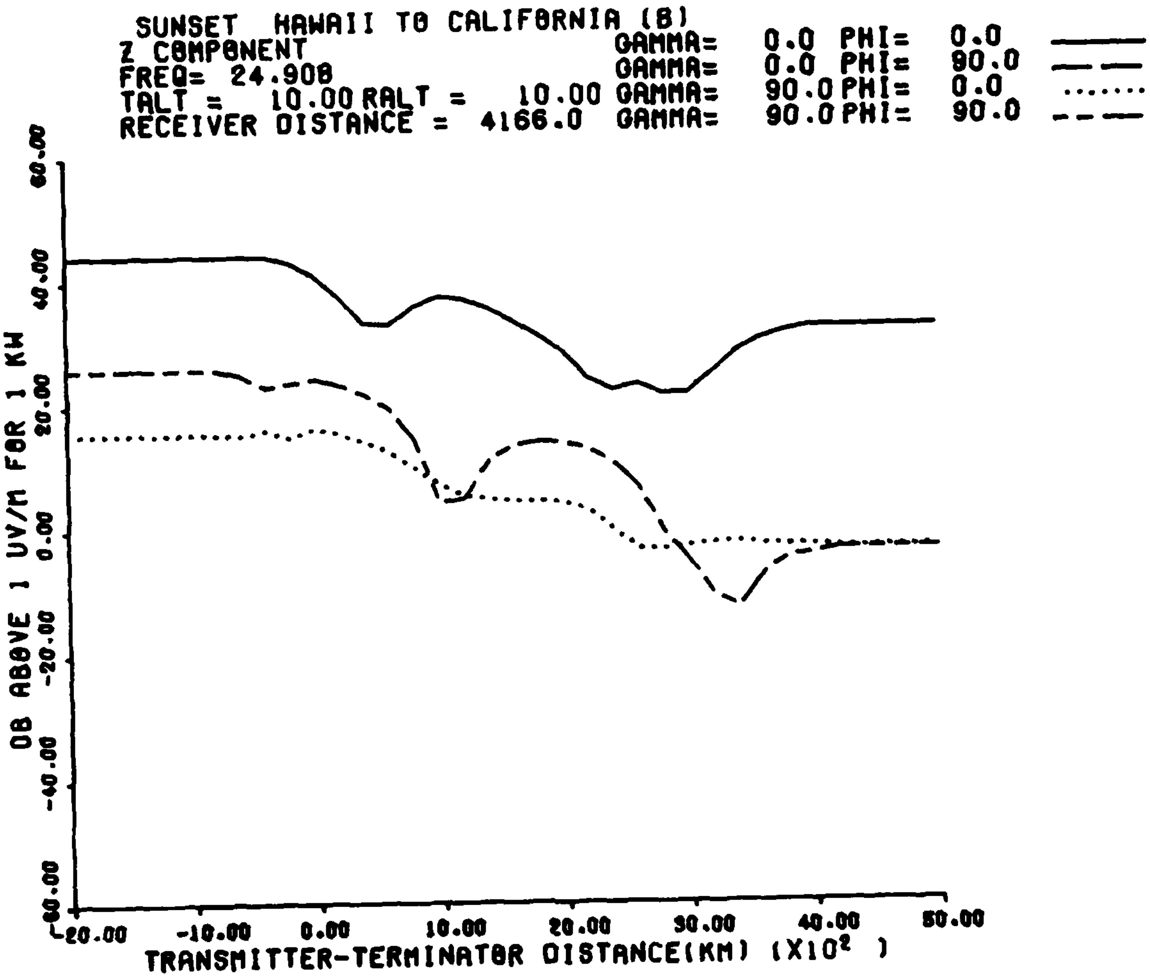


Figure 7. Continued.

c.

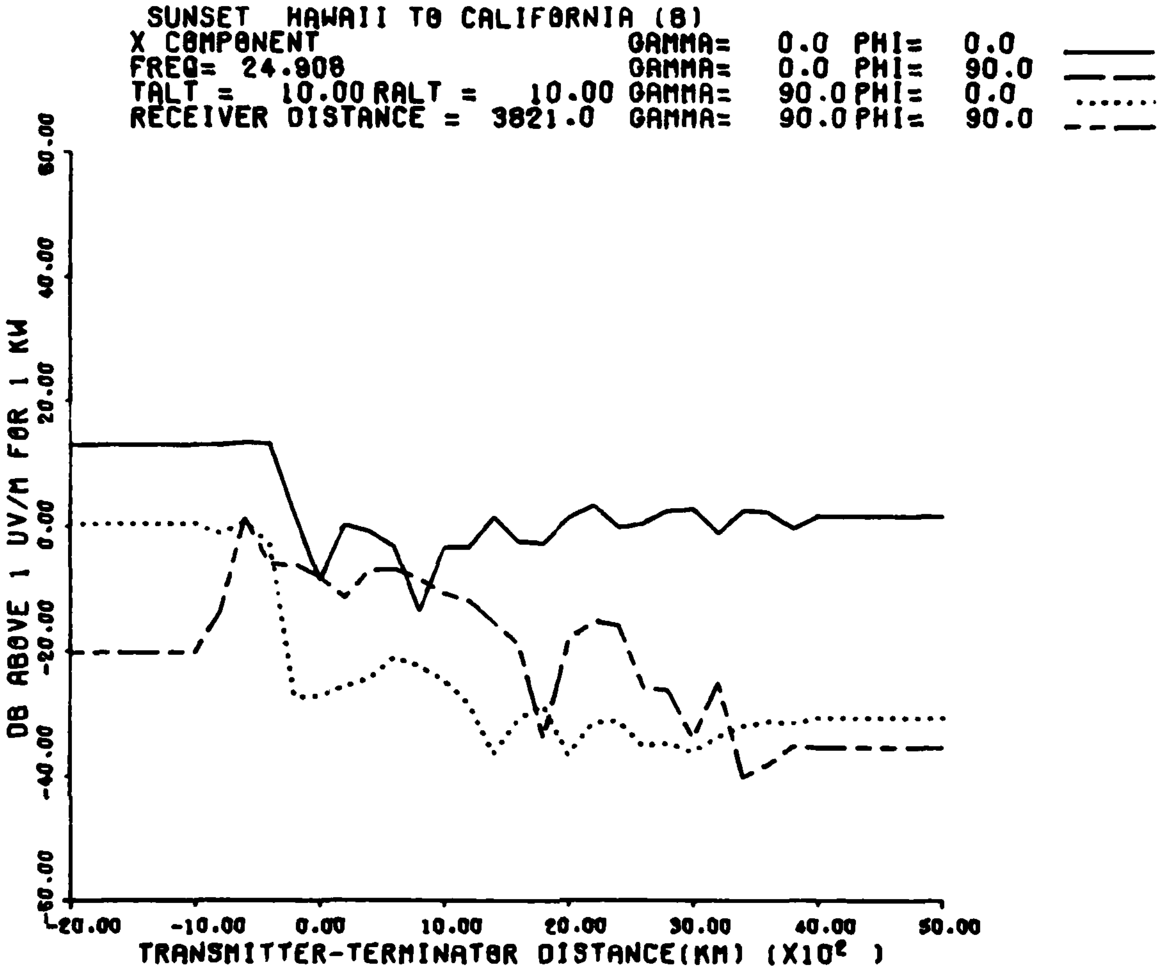


Figure 7. Continued.

d.

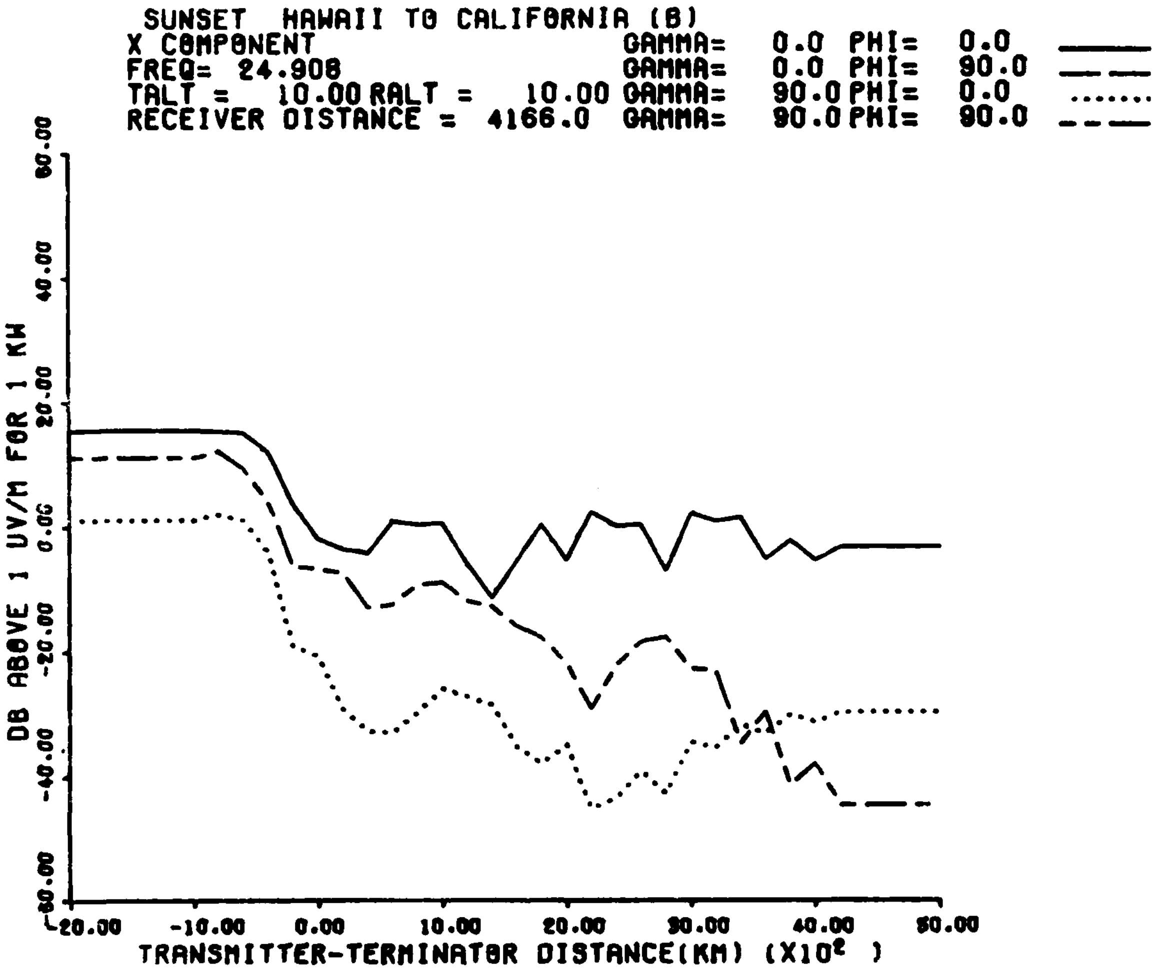


Figure 7. Continued.

e.

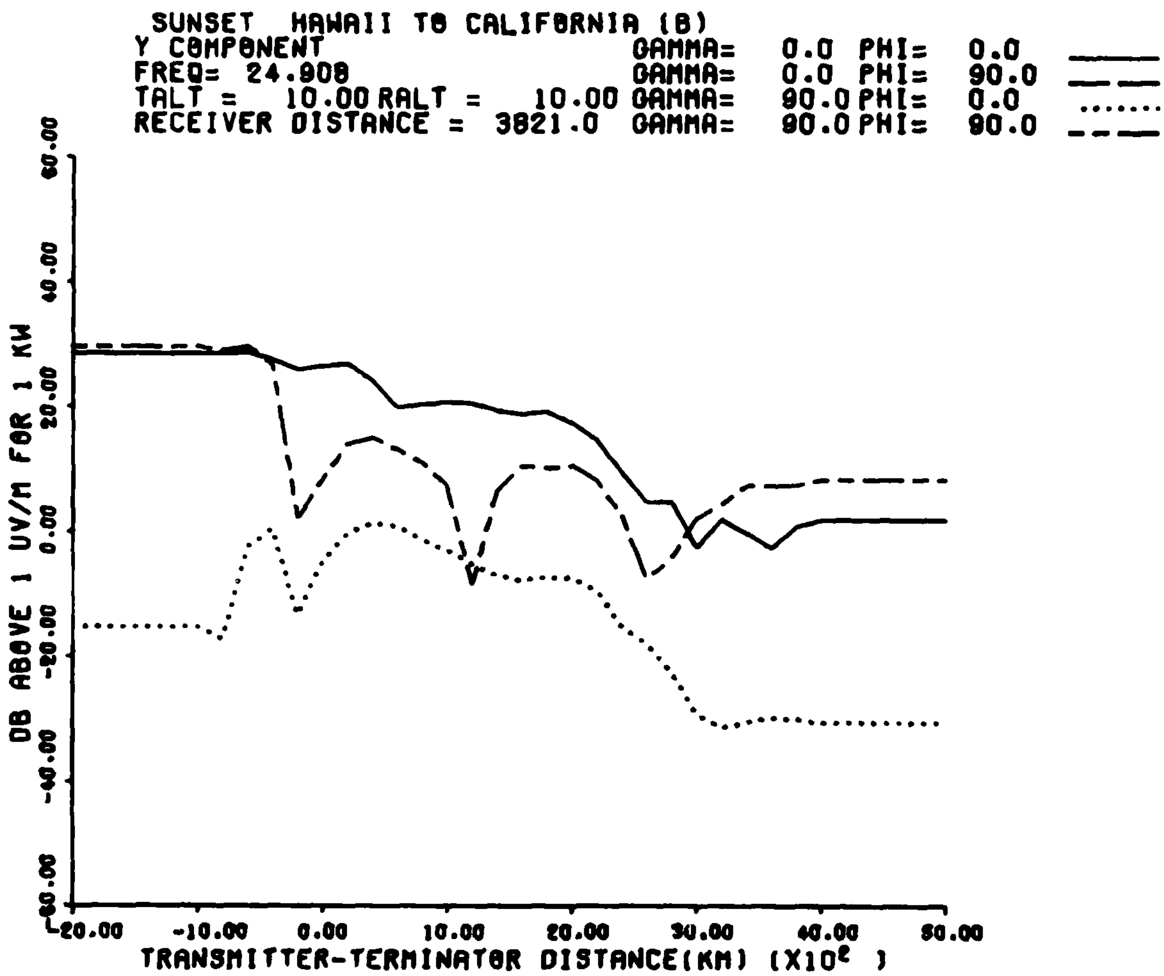


Figure 7. Continued.

f.

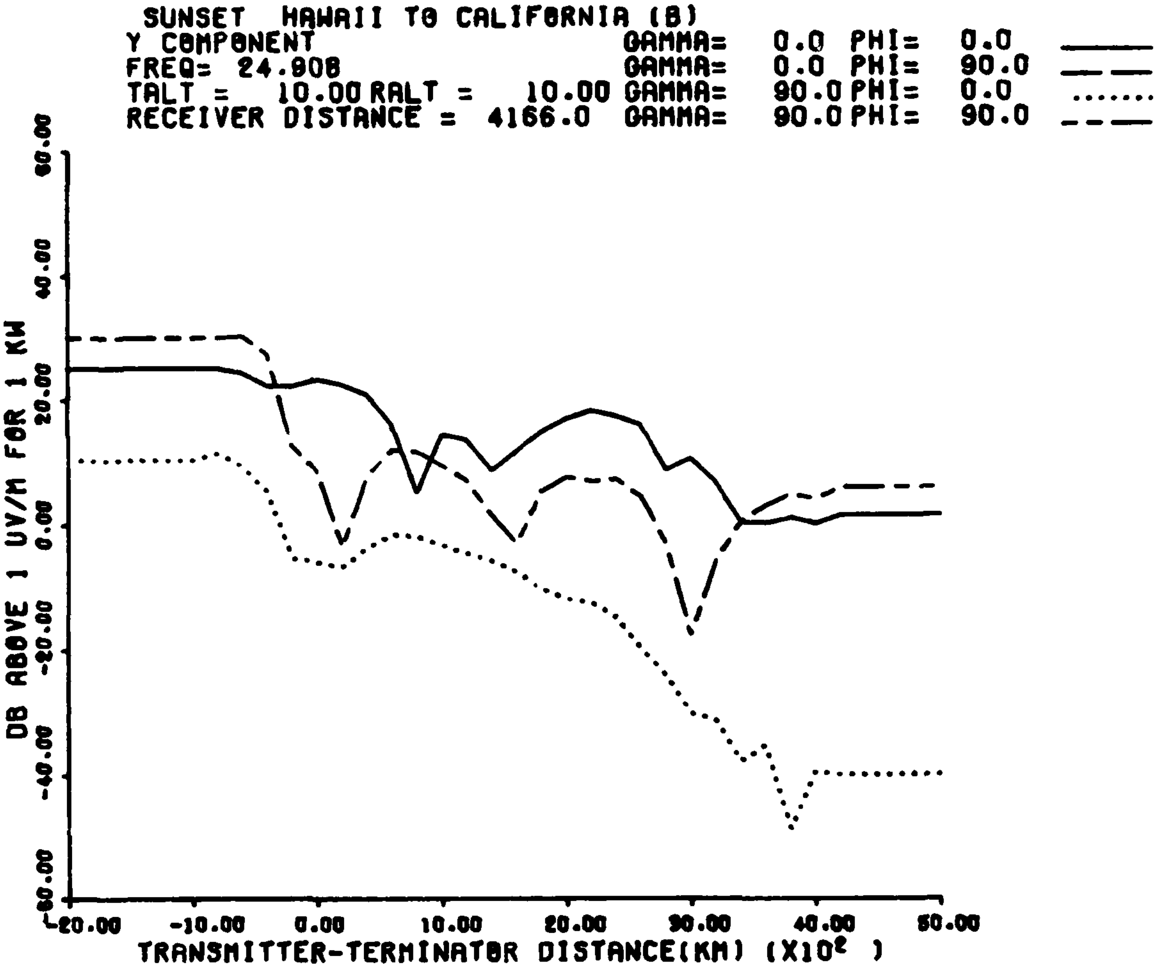


Figure 7. Continued.

VII. EXAMPLES:

```
@ELT,IL    .DATA
ELTOT7 RLIB70 11/16-14:10:18-(,0)
000001     000   NAME
000002     000    &DATUM
000003     000    RALT=6.0,TALT=0.0,
000004     000    RHOMIN=25.0,RHOMAX=4000.0,DELRHO=25.0,DELTAX=0.0,NTMAX=1,
000005     000    YMIN= 0.0,YINC=10.0,SIZEY=8.0,
000006     000    XMIN=0.0,XINC= 500.0,SIZEX=8.0,
000007     000    IPLTOP=2,
000008     000    XVAL=0.0,2362.0,3100.0,
000009     000    INTFLG=1,IPRNTA=1,IPRINT=3,
000010     000    &END
000011     000   DATA
000012     000    PRESTON U.K. TO SONDRESTROM
000013     000   R    .000 F 45.0000 A 327.000 C   16.000 M 4.880-005 S 4.640+000 E 81.0 T 72.0
000014     000   1 89.50432 -5.227691 7.68876547-004-4.26460101-004-4.61901351-013 7.40599478-015
000015     000   2 89.50432 -5.227691 1.45820227-008 1.14923771-008 3.33171375-001 1.13017417+000
000016     000   1 89.40350 -5.200752 5.63612475-005-1.35457367-004-1.79595751-012-2.75158490-012
000017     000   2 89.40350 -5.200752-1.35356545-008-1.50147295-008 3.34419385-001 1.13127953+000
000018     000   1 88.91054 -2.218521 4.29461064-003-1.67934627-002 5.28265078-015-8.55301200-014
000019     000   2 88.91054 -2.218521 1.61962495-008 3.17616551-008 3.62748194-001 1.11109295+000
000020     000   1 87.10400 -1.671932 1.09891278-004 1.15719124-006-4.58354318-011-2.50519232-011
000021     000   2 87.10400 -1.671932-2.50226939-008-6.53956631-008 3.78527377-001 1.10809810+000
000022     000   1 84.64228 -1.091651 4.73942978-005-2.01432505-002 3.34786825-013-5.50729736-013
000023     000   2 84.64228 -1.091651 3.45471309-008 1.00020680-007 4.05488681-001 1.08655921+000
000024     000
000025     000   R    .000 F 45.0000 A 327.000 C   16.000 M 4.880-005 S 1.000-005 E   5.0 T 72.0
000026     000   1 89.45821 -5.220001-3.05389572-005 1.94569473-005-4.24437047-007 2.04047108-007
000027     000   2 89.45821 -5.220001 1.55486676-006-3.47085549-006 3.33677202-001 1.13072252+000
000028     000   1 89.39362 -5.190092-5.42995645-006 2.41254750-005-7.01709098-007-3.86857682-007
000029     000   2 89.39362 -5.190092-1.98778773-006 3.58369294-006 3.34649585-001 1.13131280+000
000030     000   1 87.17955 -1.683672 2.34356839-005 1.85876675-004-1.24044903-005 2.54552359-006
000031     000   2 87.17955 -1.683672 1.49351329-008-4.50114076-005 3.77780918-001 1.10834308+000
000032     000   1 86.97608 -1.835991-1.24181321-004 6.18604543-004-3.97761204-006 1.58550104-006
000033     000   2 86.97608 -1.835991-3.56925250-006 4.78608781-005 3.80167946-001 1.10961270+000
000034     000
000035     000   R    .000 F 45.0000 A 327.000 C   16.000 M 4.880-005 S 4.640+000 E 81.0 T 72.0
000036     000   1 89.50432 -5.227691 7.68876547-004-4.26460101-004-4.61901351-013 7.40599478-015
000037     000   2 89.50432 -5.227691 1.45820227-008 1.14923771-008 3.33171375-001 1.13017417+000
000038     000   1 89.40350 -5.200752 5.63612475-005-1.35457367-004-1.79595751-012-2.75158490-012
000039     000   2 89.40350 -5.200752-1.35356545-008-1.50147295-008 3.34419385-001 1.13127953+000
000040     000   1 88.91054 -2.218521 4.29461064-003-1.67934627-002 5.28265078-015-8.55301200-014
000041     000   2 88.91054 -2.218521 1.61962495-008 3.17616551-008 3.62748194-001 1.11109295+000
000042     000   1 87.10400 -1.671932 1.09891278-004 1.15719124-006-4.58354318-011-2.50519232-011
000043     000   2 87.10400 -1.671932-2.50226939-008-6.53956631-008 3.78527377-001 1.10809810+000
000044     000   1 84.64228 -1.091651 4.73942978-005-2.01432505-002 3.34786825-013-5.50729736-013
000045     000   2 84.64228 -1.091651 3.45471309-008 1.00020680-007 4.05488681-001 1.08655921+000
000046     000
000047     000   R  40.0
000048     000   START
000049     000   QUIT

END ELT.

@XQT
```

Example II

```
@ELT,IL     .DATA
ELT0T7 RLIB70 11/16-15:00:26-(,0)
000   NAME
000    &DATUM
000    RHOMIN=3821.0,DELRHO=345.0,RHOMAX=4166.0,
000    YMIN=-60.0,YINC=20.0,SIZEY=6.0,
000    XMIN=-2000.0,XINC=1000.0,SIZEX=7.0,
000    NTMAX=36,
000    DELTAX=200.0,
000    IPLTOP=1,
000    XVAL=-9999.9,-2000.0,-1900.0,-1800.0,        -1700.0,-1600.0,-1500.0,
000    -1400.0,-1300.0,-1200.0,-1100.0,
000    NRP=4,INCL=0.0,0.0,90.0,90.0,THETA=0.0,90.0,0.0,90.0,RALT=10.0,TALT=10.0,
000    ICOMP=1,
000    NPRINT=1,
000    &END
000   DATA
000    SUNSET  HAWAII TO CALIFORNIA (B)
000   R   .000 F 24.9080 A  58.500 C  39.000 M 4.310-005 S 4.640+000 E 81.0 T 72.0
000   1 89.50228 -3.949371 4.01834643-003-1.45941476-002-3.21488204-014-2.71099228-014
000   2 89.50228 -3.949371 2.97444098-008 1.57056856-008 1.44856986-003 5.62508024-001
000   1 88.45056 -2.793042 4.90026446-005-3.57934478-005-3.75529642-011-1.73137010-011
000   2 88.45056 -2.793042-5.14926111-008-4.26912674-008 6.99930143-003 5.60824469-001
000   1 83.87948  -.999671 1.24844239-003-3.34348120-002-1.58353786-014-2.32674885-013
000   2 83.87948  -.999671 8.36879126-008 8.49086348-008 2.47631974-002 5.48166797-001
000
000   R   .000 F 24.9080 A  58.500 C  39.000 M 4.310-005 S 4.640+000 E 81.0 T 73.6
000   1 89.56593 -4.194881 3.45416329-003-1.24603144-002-8.25125956-014-3.61650941-014
000   2 89.56593 -4.194881 4.62500633-008 2.23263874-008 9.44824135-002 4.31479137-001
000   1 88.79248 -3.302542 7.32344033-005-8.81090973-005-3.02408931-011-1.39657234-011
000   2 88.79248 -3.302542-7.23936955-008-5.82158268-008 1.00134447-001 4.30736296-001
000   1 84.38084  -.900261 1.10526511-003-3.27714812-002-9.20516020-014-3.22648473-013
000   2 84.38084  -.900261 1.10233700-007 1.14599680-007 1.21486979-001 4.17771995-001
000
000   R   .000 F 24.9080 A  58.500 C  39.000 M 4.310-005 S 4.640+000 E 81.0 T 75.0
000   1 89.61513 -4.410681 2.97405102-003-1.06031664-002-1.98548680-013-3.95199252-015
000   2 89.61513 -4.410681 6.80866794-008 3.10826649-008 2.08461858-001 3.30080621-001
000   1 89.01158 -3.747542 7.26079388-005-2.08430956-004-2.43904645-011-1.13450050-011
000   2 89.01158 -3.747542-9.61152224-008-7.64947146-008 2.13588294-001 3.30451533-001
000   1 84.82569  -.817361 1.00102370-003-3.20875286-002-2.61337752-013-4.34048105-013
000   2 84.82569  -.817361 1.33410227-007 1.51954588-007 2.37778708-001 3.18923160-001
000
000   R   .000 F 24.9080 A  58.500 C  39.000 M 4.310-005 S 4.640+000 E 81.0 T 76.6
000   1 89.65634 -4.648291 2.61817023-003-8.54307879-003-5.22449217-013 2.34520313-013
000   2 89.65634 -4.648291 1.00707582-007 4.51343940-008 3.45911697-001 2.38464644-001
000   1 89.19761 -4.190722-4.64921609-005-5.37509986-004-1.87341683-011-8.96229000-012
000   2 89.19761 -4.190722-1.27865320-007-1.00297346-007 3.50060176-001 2.39703469-001
000   1 85.31089  -.741521 8.88046881-004-3.11639938-002-6.38172430-013-6.45818536-013
000   2 85.31089  -.741521 1.53155687-007 2.01567158-007 3.76868539-001 2.30326056-001
000   1 82.63814 -1.051702 3.43103315-004-4.19137210-004-1.46933299-010-3.92660787-011
```

```
000049      000   2 82.63814 -1.051702-2.28603236-007-3.55231165-007 4.00634073-001 2.29378259-001
000050      000   1 79.37213  -.799941 1.85343108-005-2.71129482-002-6.23845653-012-7.04668252-012
000051      000   2 79.37213  -.799941 4.01944931-007 5.96470336-007 4.41527899-001 2.19859788-001
000052      000
000053      000   R   .000 F 24.9080 A  58.500 C  39.000 M 4.310-005 S 4.640+000 E 81.0 T 78.0
000054      000   1 89.69031 -4.875951 2.46041792-003-6.44835515-003-1.31332143-012 8.07163018-013
000055      000   2 89.69031 -4.875951 1.26173079-007 7.00225478-008 4.76195354-001 1.85205651-001
000056      000   1 89.35652 -4.525502-3.06965645-004-1.23455383-003-1.41507338-011-7.28360655-012
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000065      000   R   .000 F 24.9080 A  58.500 C  39.000 M 4.310-005 S 4.640+000 E 81.0 T 79.6
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000091      000   2 75.72210  -.536421 6.62746544-007 1.30052034-006 8.88978459-001 1.35214640-001
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000103   000   2 81.18239  -.418231 3.31291361-007 7.07726464-007 9.02894214-001 1.21887835-001
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000      NAME
000       &DATUM
000        ICOMP=2,
000       &END
000      START
000      NAME
000       &DATUM
000        ICOMP=3,
000       &END
000      START
000      QUIT

END ELT.

@XQT
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 XMIN=0.0,XINC= 500.0,SIZEX=8.0,
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DATA
 PRESTON U.K. TO SONDRESTROM

SLAB  1 R   .000 F 45.0000 A 327.000 C  16.000 M  .488 S 4.640+000 E 81.0 T 72.0 MODES  5

SLAB  2 R   .000 F 45.0000 A 327.000 C  16.000 M  .488 S 1.000-005 E  5.0 T 72.0 MODES  4

SLAB  3 R   .000 F 45.0000 A 327.000 C  16.000 M  .488 S 4.640+000 E 81.0 T 72.0 MODES  5

START

INTEGRALS IN SLAB  1

NORM( 1, 1, 1) =  .553704+003 -.850083+003          1.01451+003   303.08
NORM( 1, 1, 2) =  .114505+004 -.167189+003          1.15720+003   351.69
NORM( 1, 1, 3) =-.207659+002 -.149617+002           2.55944+001   215.77
NORM( 1, 1, 4) =-.939482+002 -.147971+003           1.75276+002   237.59
NORM( 1, 1, 5) =  .235873+002  .225954+002          3.26636+001    43.77
NORM( 1, 2, 1) =  .114505+004 -.167189+003          1.15720+003   351.69
NORM( 1, 2, 2) =  .109398+004 -.630510+004          6.39930+003   279.84
NORM( 1, 2, 3) =-.227978+002 -.168900+001           2.28602+001   184.24
NORM( 1, 2, 4) =-.751812+003  .684891+003           1.01700+003   137.67
NORM( 1, 2, 5) =  .314290+002  .129280+002          3.39840+001    22.36
NORM( 1, 3, 1) =-.207659+002 -.149617+002           2.55944+001   215.77
NORM( 1, 3, 2) =-.227978+002 -.168900+001           2.28602+001   184.24
NORM( 1, 3, 3) =  .565552+002 -.986123+001          5.74085+001   350.11
NORM( 1, 3, 4) =  .411092+002  .184084+002          4.50426+001    24.12
NORM( 1, 3, 5) =-.241909+001 -.582611+001           6.30837+000   247.45
NORM( 1, 4, 1) =-.939482+002 -.147971+003           1.75276+002   237.59
NORM( 1, 4, 2) =-.751812+003  .684891+003           1.01700+003   137.67
NORM( 1, 4, 3) =  .411092+002  .184084+002          4.50426+001    24.12
NORM( 1, 4, 4) =-.691583+004 -.359842+004           7.79598+003   207.49
NORM( 1, 4, 5) =  .215047+001  .269595+002          2.70451+001    85.44
NORM( 1, 5, 1) =  .235873+002  .225954+002          3.26636+001    43.77
NORM( 1, 5, 2) =  .314290+002  .129280+002          3.39840+001    22.36
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NORM( 1, 5, 3) = -.241909+001 -.582611+001          6.30837+000   247.45
NORM( 1, 5, 4) =  .215047+001  .269595+002          2.70451+001    85.44
NORM( 1, 5, 5) =  .515578+002  .784454+001          5.21512+001     8.65

               INORM = NORMALIZED CONVERSION COEFFICIENTS     SLAB NUMBER =  1

J = 1   K = 1   INORM =     .00000      .00000      .00000      .00
J = 2   K = 1   INORM =     .00000      .00000      .00000      .00
J = 3   K = 1   INORM =     .00000      .00000      .00000      .00
J = 4   K = 1   INORM =     .00000      .00000      .00000      .00
J = 5   K = 1   INORM =     .00000      .00000      .00000      .00
J = 1   K = 2   INORM =     .00000      .00000      .00000      .00
J = 2   K = 2   INORM =     .00000      .00000      .00000      .00
J = 3   K = 2   INORM =     .00000      .00000      .00000      .00
J = 4   K = 2   INORM =     .00000      .00000      .00000      .00
J = 5   K = 2   INORM =     .00000      .00000      .00000      .00
J = 1   K = 3   INORM =     .00000      .00000      .00000      .00
J = 2   K = 3   INORM =     .00000      .00000      .00000      .00
J = 3   K = 3   INORM =     .00000      .00000      .00000      .00
J = 4   K = 3   INORM =     .00000      .00000      .00000      .00
J = 5   K = 3   INORM =     .00000      .00000      .00000      .00
J = 1   K = 4   INORM =     .00000      .00000      .00000      .00
J = 2   K = 4   INORM =     .00000      .00000      .00000      .00
J = 3   K = 4   INORM =     .00000      .00000      .00000      .00
J = 4   K = 4   INORM =     .00000      .00000      .00000      .00
J = 5   K = 4   INORM =     .00000      .00000      .00000      .00
J = 1   K = 5   INORM =     .00000      .00000      .00000      .00
J = 2   K = 5   INORM =     .00000      .00000      .00000      .00
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J = 3   K = 5   INORM =      .00000          .00000            .00000          .00

J = 4   K = 5   INORM =      .00000          .00000            .00000          .00

J = 5   K = 5   INORM =      .00000          .00000            .00000          .00

INTEGRALS IN SLAB  2

NORM( 2, 1, 1) = -.689634+004  .150117+005              1.65200+004    114.67
NORM( 2, 1, 2) = -.206584+005 -.400823+004              2.10437+004    190.98
NORM( 2, 1, 3) =  .101721+004 -.549927+002              1.01869+003    356.91
NORM( 2, 1, 4) =  .272916+003  .823991+003              8.68011+002     71.67
NORM( 2, 2, 1) = -.206584+005 -.400823+004              2.10437+004    190.98
NORM( 2, 2, 2) = -.263655+005  .321492+005              4.15778+004    129.36
NORM( 2, 2, 3) = -.893243+003 -.148881+003              9.05565+002    189.46
NORM( 2, 2, 4) =  .940967+003  .473870+003              1.05355+003     26.73
NORM( 2, 3, 1) =  .101721+004 -.549927+002              1.01869+003    356.91
NORM( 2, 3, 2) = -.893243+003 -.148881+003              9.05565+002    189.46
NORM( 2, 3, 3) = -.345989+004  .268547+004              4.37980+003    142.18
NORM( 2, 3, 4) = -.871953+003 -.102474+004              1.34551+003    229.61
NORM( 2, 4, 1) =  .272916+003  .823991+003              8.68011+002     71.67
NORM( 2, 4, 2) =  .940967+003  .473870+003              1.05355+003     26.73
NORM( 2, 4, 3) = -.871953+003 -.102474+004              1.34551+003    229.61
NORM( 2, 4, 4) = -.130083+004  .307805+003              1.33675+003    166.69
CAPI( 2, 1, 1) =  .341939+004  .224884+004              4.09262+003     33.33
CAPI( 2, 1, 2) = -.327542+004  .681924+004              7.56508+003    115.66
CAPI( 2, 1, 3) =  .121793+003 -.185656+003              2.22040+002    303.27
CAPI( 2, 1, 4) =  .136890+004 -.278664+003              1.39697+003    348.49
CAPI( 2, 1, 5) = -.114003+003  .360228+002              1.19559+002    162.46
CAPI( 2, 2, 1) =  .146325+004  .405022+004              4.30643+003     70.14
CAPI( 2, 2, 2) =  .141756+005  .629266+004              1.55095+004     23.94
CAPI( 2, 2, 3) =  .887340+002 -.189714+003              2.09440+002    295.07
CAPI( 2, 2, 4) = -.102817+004 -.213743+004              2.37186+003    244.31
CAPI( 2, 2, 5) = -.874805+002  .553245+002              1.03507+002    147.69
CAPI( 2, 3, 1) = -.781335+001 -.744881+002              7.48968+001    264.01
CAPI( 2, 3, 2) = -.522166+002  .589446+003              5.91754+002     95.06
CAPI( 2, 3, 3) =  .513539+002  .254595+003              2.59723+002     78.60
CAPI( 2, 3, 4) = -.502198+004  .123886+004              5.17253+003    166.14
CAPI( 2, 3, 5) =  .736899+002 -.113204+003              1.35075+002    303.06
CAPI( 2, 4, 1) =  .132357+003 -.330573+002              1.36423+002    345.98
CAPI( 2, 4, 2) =  .704631+001 -.271107+003              2.71199+002    271.49
CAPI( 2, 4, 3) =  .323507+002  .231715+003              2.33962+002     82.05
CAPI( 2, 4, 4) =  .149650+004 -.619506+003              1.61966+003    337.51
CAPI( 2, 4, 5) =  .617325+002 -.131186+003              1.44985+002    295.20

               INORM = NORMALIZED CONVERSION COEFFICIENTS      SLAB NUMBER =  2

J = 1   K = 1   INORM =   -2.57981-003   -1.92246-001      1.92264-001   269.23
```

J = 2	K = 1	INORM =	-3.10839-002	-4.14087-002	5.17773-002	233.11
J = 3	K = 1	INORM =	-1.35819-005	-1.48235-002	1.48235-002	269.95
J = 4	K = 1	INORM =	1.11251-002	-4.52524-002	4.65999-002	283.81
J = 1	K = 2	INORM =	-1.57271-002	1.57387-001	1.58170-001	95.71
J = 2	K = 2	INORM =	-2.44277-002	-3.90130-001	3.90894-001	266.42
J = 3	K = 2	INORM =	-1.47137-003	-1.64146-002	1.64804-002	264.88
J = 4	K = 2	INORM =	1.45132-002	-4.40381-002	4.63679-002	288.24
J = 1	K = 3	INORM =	-2.95272-003	1.13780-003	3.16435-003	158.93
J = 2	K = 3	INORM =	-9.94993-004	1.83987-003	2.09168-003	118.40
J = 3	K = 3	INORM =	-1.65526-002	-4.55370-002	4.84521-002	250.02
J = 4	K = 3	INORM =	-1.92979-002	-1.39794-001	1.41120-001	262.14
J = 1	K = 4	INORM =	-6.01359-004	1.29700-003	1.42963-003	114.87
J = 2	K = 4	INORM =	-6.92692-004	1.04526-003	1.25395-003	123.53
J = 3	K = 4	INORM =	8.18196-001	7.64483-001	1.11977+000	43.06
J = 4	K = 4	INORM =	-8.87768-001	-8.90408-001	1.25736+000	225.09

INTEGRALS IN SLAB 3

NORM(3, 1, 1) =	.553704+003	-.850083+003	1.01451+003	303.08
NORM(3, 1, 2) =	.114505+004	-.167189+003	1.15720+003	351.69
NORM(3, 1, 3) =	-.207659+002	-.149617+002	2.55944+001	215.77
NORM(3, 1, 4) =	-.939482+002	-.147971+003	1.75276+002	237.59
NORM(3, 1, 5) =	.235873+002	.225954+002	3.26636+001	43.77
NORM(3, 2, 1) =	.114505+004	-.167189+003	1.15720+003	351.69
NORM(3, 2, 2) =	.109398+004	-.630510+004	6.39930+003	279.84
NORM(3, 2, 3) =	-.227978+002	-.168900+001	2.28602+001	184.24
NORM(3, 2, 4) =	-.751812+003	.684891+003	1.01700+003	137.67
NORM(3, 2, 5) =	.314290+002	.129280+002	3.39840+001	22.36
NORM(3, 3, 1) =	-.207659+002	-.149617+002	2.55944+001	215.77
NORM(3, 3, 2) =	-.227978+002	-.168900+001	2.28602+001	184.24
NORM(3, 3, 3) =	.565552+002	-.986123+001	5.74085+001	350.11
NORM(3, 3, 4) =	.411092+002	.184084+002	4.50426+001	24.12
NORM(3, 3, 5) =	-.241909+001	-.582611+001	6.30837+000	247.45
NORM(3, 4, 1) =	-.939482+002	-.147971+003	1.75276+002	237.59
NORM(3, 4, 2) =	-.751812+003	.684891+003	1.01700+003	137.67

NORM(3, 4, 3) =	.411092+002	.184084+002	4.50426+001	24.12
NORM(3, 4, 4) =	-.691583+004	-.359842+004	7.79598+003	207.49
NORM(3, 4, 5) =	.215047+001	.269595+002	2.70451+001	85.44
NORM(3, 5, 1) =	.235873+002	.225954+002	3.26636+001	43.77
NORM(3, 5, 2) =	.314290+002	.129280+002	3.39840+001	22.36
NORM(3, 5, 3) =	-.241909+001	-.582611+001	6.30837+000	247.45
NORM(3, 5, 4) =	.215047+001	.269595+002	2.70451+001	85.44
NORM(3, 5, 5) =	.515578+002	.784454+001	5.21512+001	8.65
CAPI(3, 1, 1) =	.341939+004	.224884+004	4.09262+003	33.33
CAPI(3, 1, 2) =	.146325+004	.405022+004	4.30643+003	70.14
CAPI(3, 1, 3) =	-.781335+001	-.744881+002	7.48968+001	264.01
CAPI(3, 1, 4) =	.132357+003	-.330573+002	1.36423+002	345.98
CAPI(3, 2, 1) =	-.327542+004	.681924+004	7.56508+003	115.66
CAPI(3, 2, 2) =	.141756+005	.629266+004	1.55095+004	23.94
CAPI(3, 2, 3) =	-.522166+002	.589446+003	5.91754+002	95.06
CAPI(3, 2, 4) =	.704631+001	-.271107+003	2.71199+002	271.49
CAPI(3, 3, 1) =	.121793+003	-.185656+003	2.22040+002	303.27
CAPI(3, 3, 2) =	.887340+002	-.189714+003	2.09440+002	295.07
CAPI(3, 3, 3) =	.513539+002	.254595+003	2.59723+002	78.60
CAPI(3, 3, 4) =	.323507+002	.231715+003	2.33962+002	82.05
CAPI(3, 4, 1) =	.136890+004	-.278664+003	1.39697+003	348.49
CAPI(3, 4, 2) =	-.102817+004	-.213743+004	2.37186+003	244.31
CAPI(3, 4, 3) =	-.502198+004	.123886+004	5.17253+003	166.14
CAPI(3, 4, 4) =	.149650+004	-.619506+003	1.61966+003	337.51
CAPI(3, 5, 1) =	-.114003+003	.360228+002	1.19559+002	162.46
CAPI(3, 5, 2) =	-.874805+002	.553245+002	1.03507+002	147.69
CAPI(3, 5, 3) =	.736899+002	-.113204+003	1.35075+002	303.06
CAPI(3, 5, 4) =	.617325+002	-.131186+003	1.44985+002	295.20

INORM = NORMALIZED CONVERSION COEFFICIENTS SLAB NUMBER = 3

J = 1	K = 1	INORM =	-2.39980-001	4.73044+000	4.73652+000	92.90
J = 2	K = 1	INORM =	-3.08277-001	-5.45127-001	6.26257-001	240.51
J = 3	K = 1	INORM =	1.09296+000	-1.67666+000	2.00144+000	303.10
J = 4	K = 1	INORM =	8.04651-003	-1.16064-003	8.12979-003	351.79
J = 5	K = 1	INORM =	1.21527-001	-9.28489-001	9.36408-001	277.46
J = 1	K = 2	INORM =	-3.82853-001	1.87386+000	1.91257+000	101.55
J = 2	K = 2	INORM =	-2.44327-001	2.31412+000	2.32698+000	96.03
J = 3	K = 2	INORM =	1.15439+000	-1.67388+000	2.03334+000	304.59
J = 4	K = 2	INORM =	8.85291-003	4.77432-003	1.00582-002	28.34
J = 5	K = 2	INORM =	1.31443-001	-9.38743-001	9.47900-001	277.97

J = 1	K = 3	INORM =	-8.08345-002	2.32540-002	8.41129-002	163.95
J = 2	K = 3	INORM =	-7.09757-003	1.37870-002	1.55067-002	117.24
J = 3	K = 3	INORM =	-1.74859-001	4.54218+000	4.54554+000	92.20
J = 4	K = 3	INORM =	5.06520-001	-4.16186-001	6.55571-001	320.59
J = 5	K = 3	INORM =	3.75751-001	-2.28882+000	2.31946+000	279.32
J = 1	K = 4	INORM =	-7.61342-002	2.65349-002	8.06258-002	160.79
J = 2	K = 4	INORM =	-7.59287-003	1.25994-002	1.47105-002	121.07
J = 3	K = 4	INORM =	2.47582-001	4.00187+000	4.00952+000	86.46
J = 4	K = 4	INORM =	-1.22341-001	1.78256-001	2.16201-001	124.46
J = 5	K = 4	INORM =	5.53141-001	-2.34087+000	2.40533+000	283.29
J = 1	K = 5	INORM =	.00000	.00000	.00000	.00
J = 2	K = 5	INORM =	.00000	.00000	.00000	.00
J = 3	K = 5	INORM =	.00000	.00000	.00000	.00
J = 4	K = 5	INORM =	.00000	.00000	.00000	.00
J = 5	K = 5	INORM =	.00000	.00000	.00000	.00

A = TOTAL CONVERSION COEFFICIENTS SLAB NUMBER = 1

J = 1	K = 1	A =	1.00000+000	.00000	1.00000+000	.00
J = 2	K = 1	A =	.00000	.00000	.00000	.00
J = 3	K = 1	A =	.00000	.00000	.00000	.00
J = 4	K = 1	A =	.00000	.00000	.00000	.00
J = 5	K = 1	A =	.00000	.00000	.00000	.00
J = 1	K = 2	A =	.00000	.00000	.00000	.00
J = 2	K = 2	A =	1.00000+000	.00000	1.00000+000	.00
J = 3	K = 2	A =	.00000	.00000	.00000	.00
J = 4	K = 2	A =	.00000	.00000	.00000	.00

J = 5	K = 2	A =	.00000	.00000	.00000	.00
J = 1	K = 3	A =	.00000	.00000	.00000	.00
J = 2	K = 3	A =	.00000	.00000	.00000	.00
J = 3	K = 3	A =	1.00000+000	.00000	1.00000+000	.00
J = 4	K = 3	A =	.00000	.00000	.00000	.00
J = 5	K = 3	A =	.00000	.00000	.00000	.00
J = 1	K = 4	A =	.00000	.00000	.00000	.00
J = 2	K = 4	A =	.00000	.00000	.00000	.00
J = 3	K = 4	A =	.00000	.00000	.00000	.00
J = 4	K = 4	A =	1.00000+000	.00000	1.00000+000	.00
J = 5	K = 4	A =	.00000	.00000	.00000	.00
J = 1	K = 5	A =	.00000	.00000	.00000	.00
J = 2	K = 5	A =	.00000	.00000	.00000	.00
J = 3	K = 5	A =	.00000	.00000	.00000	.00
J = 4	K = 5	A =	.00000	.00000	.00000	.00
J = 5	K = 5	A =	1.00000+000	.00000	1.00000+000	.00

A = TOTAL CONVERSION COEFFICIENTS SLAB NUMBER = 2

J = 1	K = 1	A =	-2.57981-003	-1.92246-001	1.92264-001	269.23
J = 2	K = 1	A =	-3.10839-002	-4.14087-002	5.17773-002	233.11
J = 3	K = 1	A =	-1.35819-005	-1.48235-002	1.48235-002	269.95
J = 4	K = 1	A =	1.11251-002	-4.52524-002	4.65999-002	283.81
J = 1	K = 2	A =	-1.57271-002	1.57387-001	1.58170-001	95.71
J = 2	K = 2	A =	-2.44277-002	-3.90130-001	3.90894-001	266.42
J = 3	K = 2	A =	-1.47137-003	-1.64146-002	1.64804-002	264.88
J = 4	K = 2	A =	1.45132-002	-4.40381-002	4.63679-002	288.24

J = 1	K = 3	A =	-2.95272-003	1.13780-003	3.16435-003	158.93
J = 2	K = 3	A =	-9.94993-004	1.83987-003	2.09168-003	118.40
J = 3	K = 3	A =	-1.65526-002	-4.55370-002	4.84521-002	250.02
J = 4	K = 3	A =	-1.92979-002	-1.39794-001	1.41120-001	262.14
J = 1	K = 4	A =	-6.01359-004	1.29700-003	1.42963-003	114.87
J = 2	K = 4	A =	-6.92692-004	1.04526-003	1.25395-003	123.53
J = 3	K = 4	A =	8.18196-001	7.64483-001	1.11977+000	43.06
J = 4	K = 4	A =	-8.87768-001	-8.90408-001	1.25736+000	225.09
J = 1	K = 5	A =	1.24895-003	6.15159-004	1.39223-003	26.22
J = 2	K = 5	A =	6.19127-004	-7.52315-004	9.74318-004	309.45
J = 3	K = 5	A =	-4.34314-003	2.29728-002	2.33798-002	100.71
J = 4	K = 5	A =	-4.45312-002	7.89346-002	9.06295-002	119.43

A = TOTAL CONVERSION COEFFICIENTS SLAB NUMBER = 3

J = 1	K = 1	A =	6.02529-002	-5.42874-001	5.46207-001	276.33
J = 2	K = 1	A =	3.18122-003	3.32733-003	4.60340-003	46.29
J = 3	K = 1	A =	-1.82599-001	2.87006-001	3.40169-001	122.47
J = 4	K = 1	A =	-7.26558-004	-1.92183-004	7.51545-004	194.82
J = 5	K = 1	A =	1.97466-002	8.80034-002	9.01916-002	77.35
J = 1	K = 2	A =	2.08716-003	2.94059-002	2.94799-002	85.94
J = 2	K = 2	A =	7.60149-002	-5.08875-001	5.14521-001	278.50
J = 3	K = 2	A =	-1.83876-001	2.60038-001	3.18481-001	125.26
J = 4	K = 2	A =	-3.62543-004	-1.97908-003	2.01202-003	259.62
J = 5	K = 2	A =	1.85462-002	7.70892-002	7.92887-002	76.47
J = 1	K = 3	A =	-1.45502-002	3.45842-003	1.49555-002	166.63
J = 2	K = 3	A =	-1.54532-003	1.72100-003	2.31297-003	131.92

J = 3	K = 3	A =	-4.25734-002	2.49893-001	2.53494-001	99.67
J = 4	K = 3	A =	1.75468-003	-1.32264-003	2.19733-003	322.99
J = 5	K = 3	A =	6.39667-002	-1.30959-001	1.45747-001	296.03
J = 1	K = 4	A =	-1.70989-003	5.04427-004	1.78274-003	163.56
J = 2	K = 4	A =	-2.05336-003	-2.59481-004	2.06969-003	187.20
J = 3	K = 4	A =	-1.24109-001	-2.79679-001	3.05979-001	246.07
J = 4	K = 4	A =	-1.36103-001	3.23642-001	3.51095-001	112.81
J = 5	K = 4	A =	1.64642-001	-1.58276-002	1.65401-001	354.51
J = 1	K = 5	A =	6.28086-003	3.15263-003	7.02768-003	26.65
J = 2	K = 5	A =	9.92403-004	-7.99324-004	1.27428-003	321.15
J = 3	K = 5	A =	1.07936-001	-1.03132-001	1.49287-001	316.30
J = 4	K = 5	A =	4.83196-004	6.25208-004	7.90167-004	52.30
J = 5	K = 5	A =	-7.65200-002	3.95076-002	8.61171-002	152.69

ELECTRIC FIELD STRENGTH AS A FUNCTION OF RHO

EZ

GAMMA(DEG)= .0 PHI(DEG)= .0 TALT(KM)= .000 RALT(KM)= 6.000

RHO(KM)	AMP(DB)	ANG(DEG)
25.00	74.36654	98.7435
50.00	71.15625	100.9405
75.00	69.16570	103.0430
100.00	67.65702	105.0526
125.00	66.39884	106.9696
150.00	65.28794	108.7934
175.00	64.26905	110.5224
200.00	63.30894	112.1535
225.00	62.38592	113.6823
250.00	61.48489	115.1025
275.00	60.59480	116.4063
300.00	59.70720	117.5832
325.00	58.81538	118.6201
350.00	57.91384	119.5005
375.00	56.99800	120.2036
400.00	56.06402	120.7038
425.00	55.10874	120.9687
450.00	54.12975	120.9584
475.00	53.12562	120.6230
500.00	52.09631	119.9017
525.00	51.04385	118.7199
550.00	49.97341	116.9896
575.00	48.89485	114.6110
600.00	47.82477	111.4794
625.00	46.78858	107.5035
650.00	45.82181	102.6358
675.00	44.96836	96.9184
700.00	44.27355	90.5255
725.00	43.77178	83.7741
750.00	43.47395	77.0711
775.00	43.36293	70.8102
800.00	43.40060	65.2770
825.00	43.54102	60.6109
850.00	43.74179	56.8273
875.00	43.96962	53.8629
900.00	44.20112	51.6183
925.00	44.42116	49.9860
950.00	44.62073	48.8649
975.00	44.79494	48.1662

1000.00	44.94155	47.8144
1025.00	45.06002	47.7465
1050.00	45.15074	47.9102
1075.00	45.21469	48.2619
1100.00	45.25310	48.7652
1125.00	45.26732	49.3893
1150.00	45.25868	50.1084
1175.00	45.22848	50.8998
1200.00	45.17791	51.7441
1225.00	45.10805	52.6244
1250.00	45.01989	53.5253
1275.00	44.91429	54.4335
1300.00	44.79201	55.3366
1325.00	44.65373	56.2236
1350.00	44.50003	57.0842
1375.00	44.33144	57.9089
1400.00	44.14843	58.6890
1425.00	43.95141	59.4161
1450.00	43.74079	60.0825
1475.00	43.51694	60.6806
1500.00	43.28027	61.2034
1525.00	43.03117	61.6441
1550.00	42.77008	61.9960
1575.00	42.49751	62.2528
1600.00	42.21399	62.4084
1625.00	41.92019	62.4568
1650.00	41.61683	62.3925
1675.00	41.30478	62.2102
1700.00	40.98501	61.9049
1725.00	40.65867	61.4723
1750.00	40.32702	60.9089
1775.00	39.99153	60.2117
1800.00	39.65378	59.3791
1825.00	39.31553	58.4107
1850.00	38.97865	57.3077
1875.00	38.64514	56.0732
1900.00	38.31704	54.7122
1925.00	37.99639	53.2321
1950.00	37.68518	51.6427
1975.00	37.38526	49.9559
2000.00	37.09825	48.1861
2025.00	36.82549	46.3495
2050.00	36.56794	44.4639
2075.00	36.32618	42.5481
2100.00	36.10032	40.6211
2125.00	35.89005	38.7019
2150.00	35.69464	36.8083
2175.00	35.51298	34.9568
2200.00	35.34368	33.1620
2225.00	35.18510	31.4361

2250.00	35.03548	29.7992
2275.00	34.89297	28.2290
2300.00	34.75574	26.7606
2325.00	34.62201	25.3875
2350.00	34.49011	24.1109
2375.00	26.20228	7.9712
2400.00	25.74950	8.8843
2425.00	25.29176	9.8499
2450.00	24.82978	10.8736
2475.00	24.36444	11.9609
2500.00	23.89675	13.1168
2525.00	23.42787	14.3460
2550.00	22.95911	15.6522
2575.00	22.49194	17.0380
2600.00	22.02796	18.5053
2625.00	21.56887	20.0540
2650.00	21.11646	21.6826
2675.00	20.67258	23.3877
2700.00	20.23904	25.1637
2725.00	19.81760	27.0029
2750.00	19.40986	28.8956
2775.00	19.01720	30.8297
2800.00	18.64074	32.7917
2825.00	18.28122	34.7664
2850.00	17.93902	36.7381
2875.00	17.61406	38.6903
2900.00	17.30589	40.6070
2925.00	17.01361	42.4730
2950.00	16.73600	44.2744
2975.00	16.47152	45.9990
3000.00	16.21841	47.6365
3025.00	15.97473	49.1789
3050.00	15.73847	50.6204
3075.00	15.50757	51.9572
3100.00	15.28000	53.1874
3125.00	16.91793	47.5218
3150.00	17.46406	43.3922
3175.00	18.01238	40.1300
3200.00	18.53882	37.5865
3225.00	19.02953	35.6219
3250.00	19.47734	34.1167
3275.00	19.87919	32.9732
3300.00	20.23437	32.1135
3325.00	20.54354	31.4760
3350.00	20.80805	31.0118
3375.00	21.02957	30.6824
3400.00	21.20992	30.4569
3425.00	21.35086	30.3109
3450.00	21.45412	30.2244
3475.00	21.52130	30.1812

3500.00	21.55391	30.1678
3525.00	21.55334	30.1733
3550.00	21.52086	30.1882
3575.00	21.45766	30.2044
3600.00	21.36486	30.2151
3625.00	21.24348	30.2141
3650.00	21.09449	30.1959
3675.00	20.91885	30.1555
3700.00	20.71745	30.0883
3725.00	20.49118	29.9897
3750.00	20.24095	29.8557
3775.00	19.96764	29.6821
3800.00	19.67221	29.4649
3825.00	19.35565	29.2000
3850.00	19.01901	28.8836
3875.00	18.66343	28.5116
3900.00	18.29017	28.0802
3925.00	17.90061	27.5855
3950.00	17.49627	27.0240
3975.00	17.07887	26.3924
4000.00	16.65028	25.6878

QUIT

END OF JOB

1 FRAMES 1787 PLOTWORDS 2 MINUTES

@BRKPT PRINT$

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NAME
 &DATUM
 RHOMIN=3821.0,DELRHO=345.0,RHOMAX=4166.0,
 YMIN=-60.0,YINC=20.0,SIZEY=6.0,
 XMIN=-2000.0,XINC=1000.0,SIZEX=7.0,
 NTMAX=36,
 DELTAX=200.0,
 IPLTOP=1,
 XVAL=-9999.9,-2000.0,-1900.0,-1800.0,        -1700.0,-1600.0,-1500.0,
 -1400.0,-1300.0,-1200.0,-1100.0,
 NRP=4,INCL=0.0,0.0,90.0,90.0,THETA=0.0,90.0,0.0,90.0,RALT=10.0,TALT=10.0,
 ICOMP=1,
 NPRINT=1,
 &END
DATA
 SUNSET  HAWAII TO CALIFORNIA (B)

SLAB  1 R   .000 F 24.9080 A  58.500 C  39.000 M  .431 S 4.640+000 E 81.0 T 72.0 MODES  3

SLAB  2 R   .000 F 24.9080 A  58.500 C  39.000 M  .431 S 4.640+000 E 81.0 T 73.6 MODES  3

SLAB  3 R   .000 F 24.9080 A  58.500 C  39.000 M  .431 S 4.640+000 E 81.0 T 75.0 MODES  3

SLAB  4 R   .000 F 24.9080 A  58.500 C  39.000 M  .431 S 4.640+000 E 81.0 T 76.6 MODES  5

SLAB  5 R   .000 F 24.9080 A  58.500 C  39.000 M  .431 S 4.640+000 E 81.0 T 78.0 MODES  5

SLAB  6 R   .000 F 24.9080 A  58.500 C  39.000 M  .431 S 4.640+000 E 81.0 T 79.6 MODES  5

SLAB  7 R   .000 F 24.9080 A  58.500 C  39.000 M  .431 S 4.640+000 E 81.0 T 81.0 MODES  7

SLAB  8 R   .000 F 24.9080 A  58.500 C  39.000 M  .431 S 4.640+000 E 81.0 T 82.6 MODES  7

SLAB  9 R   .000 F 24.9080 A  58.500 C  39.000 M  .431 S 4.640+000 E 81.0 T 84.0 MODES  9

SLAB 10 R   .000 F 24.9080 A  58.500 C  39.000 M  .431 S 4.640+000 E 81.0 T 85.6 MODES  9

SLAB 11 R   .000 F 24.9080 A  58.500 C  39.000 M  .431 S 4.640+000 E 81.0 T 87.0 MODES 11

START
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ELECTRIC FIELD STRENGTH AS A FUNCTION OF TRANSMITTER-TERMINATOR DISTANCE(D)

GAMMA(DEG)= .0 PHI(DEG)= .0 TALT(KM) = 10.000 RALT(KM) = 10.000

	FIELD AT RHOMIN		FIELD AT RHOMAX	
D	EZ(DB)	EZ(ANG)	EZ(DB)	EZ(ANG)
-2000.0	43.353	84.75	43.915	103.81
-1800.0	43.353	84.75	43.915	103.81
-1600.0	43.353	84.75	43.915	103.81
-1400.0	43.353	84.75	43.915	103.81
-1200.0	43.353	84.75	43.915	103.81
-1000.0	43.353	84.75	43.915	103.81
-800.0	43.344	84.79	43.919	103.84
-600.0	43.556	84.34	43.942	103.74
-400.0	44.370	93.62	43.986	106.75
-200.0	42.510	116.38	42.833	115.86
.0	40.498	140.24	41.001	132.96
200.0	36.620	173.72	37.369	160.87
400.0	32.351	235.70	33.154	208.19
600.0	34.765	298.00	32.783	275.07
800.0	37.416	323.92	35.758	313.73
1000.0	37.850	337.44	37.196	331.24
1200.0	37.216	349.28	36.859	338.47
1400.0	36.145	1.50	35.276	343.02
1600.0	34.923	12.84	33.283	347.12
1800.0	31.879	18.87	30.984	351.39
2000.0	24.152	31.01	28.329	346.98
2200.0	15.330	175.53	24.023	318.28
2400.0	25.443	197.41	22.322	270.50
2600.0	27.164	208.22	23.153	238.34
2800.0	28.714	213.26	21.496	214.20
3000.0	29.894	211.63	21.518	195.04
3200.0	31.199	206.60	24.936	178.35
3400.0	31.967	203.67	28.224	173.81
3600.0	32.694	201.57	30.369	170.72
3800.0	32.854	198.45	31.399	170.26
4000.0	32.594	198.48	32.153	169.62
4200.0	32.594	198.48	32.012	167.45
4400.0	32.594	198.48	32.012	167.45
4600.0	32.594	198.48	32.012	167.45
4800.0	32.594	198.48	32.012	167.45
5000.0	32.594	198.48	32.012	167.45

ELECTRIC FIELD STRENGTH AS A FUNCTION OF TRANSMITTER-TERMINATOR DISTANCE(D)

GAMMA(DEG)= .0 PHI(DEG)= 90.0 TALT(KM) = 10.000 RALT(KM) = 10.000

	FIELD AT RHOMIN		FIELD AT RHOMAX	
D	EZ(DB)	EZ(ANG)	EZ(DB)	EZ(ANG)
-2000.0	43.353	84.75	43.915	103.81
-1800.0	43.353	84.75	43.915	103.81
-1600.0	43.353	84.75	43.915	103.81
-1400.0	43.353	84.75	43.915	103.81
-1200.0	43.353	84.75	43.915	103.81
-1000.0	43.353	84.75	43.915	103.81
-800.0	43.344	84.79	43.919	103.84
-600.0	43.556	84.34	43.942	103.74
-400.0	44.370	93.62	43.986	106.75
-200.0	42.510	116.38	42.833	115.86
.0	40.498	140.24	41.001	132.96
200.0	36.620	173.72	37.369	160.87
400.0	32.351	235.70	33.154	208.19
600.0	34.765	298.00	32.783	275.07
800.0	37.416	323.92	35.758	313.73
1000.0	37.850	337.44	37.196	331.24
1200.0	37.216	349.28	36.859	338.47
1400.0	36.145	1.50	35.276	343.02
1600.0	34.923	12.84	33.283	347.12
1800.0	31.879	18.87	30.984	351.39
2000.0	24.152	31.01	28.329	346.98
2200.0	15.330	175.53	24.023	318.28
2400.0	25.443	197.41	22.322	270.50
2600.0	27.164	208.22	23.153	238.34
2800.0	28.714	213.26	21.496	214.20
3000.0	29.894	211.63	21.518	195.04
3200.0	31.199	206.60	24.936	178.35
3400.0	31.967	203.67	28.224	173.81
3600.0	32.694	201.57	30.369	170.72
3800.0	32.854	198.45	31.399	170.26
4000.0	32.594	198.48	32.153	169.62
4200.0	32.594	198.48	32.012	167.45
4400.0	32.594	198.48	32.012	167.45
4600.0	32.594	198.48	32.012	167.45
4800.0	32.594	198.48	32.012	167.45
5000.0	32.594	198.48	32.012	167.45

ELECTRIC FIELD STRENGTH AS A FUNCTION OF TRANSMITTER-TERMINATOR DISTANCE(D)

GAMMA(DEG)= 90.0 PHI(DEG)= .0 TALT(KM) = 10.000 RALT(KM) = 10.000

	FIELD AT RHOMIN		FIELD AT RHOMAX	
D	EZ(DB)	EZ(ANG)	EZ(DB)	EZ(ANG)
-2000.0	12.942	309.62	15.437	35.89
-1800.0	12.942	309.62	15.437	35.89
-1600.0	12.942	309.62	15.437	35.89
-1400.0	12.942	309.62	15.437	35.89
-1200.0	12.942	309.62	15.437	35.89
-1000.0	12.942	309.62	15.437	35.89
-800.0	13.165	312.10	15.339	35.32
-600.0	16.358	290.33	15.191	37.78
-400.0	20.803	350.38	15.985	36.65
-200.0	15.849	49.48	14.742	53.57
.0	17.224	80.61	16.361	79.79
200.0	16.358	115.73	15.400	111.70
400.0	14.976	147.10	14.152	144.95
600.0	12.644	175.20	12.389	178.23
800.0	8.856	203.76	9.905	213.84
1000.0	4.429	242.01	7.149	253.96
1200.0	1.884	291.37	5.413	297.18
1400.0	2.727	335.13	4.797	332.08
1600.0	4.622	5.30	4.451	359.76
1800.0	5.671	26.30	4.351	24.24
2000.0	4.864	47.47	4.303	45.33
2200.0	2.255	73.86	2.831	65.37
2400.0	-1.684	118.59	-.206	95.35
2600.0	-3.055	176.03	-3.439	143.54
2800.0	-1.709	224.64	-3.404	194.57
3000.0	.018	251.89	-2.969	231.08
3200.0	1.028	266.22	-2.462	255.48
3400.0	1.402	272.10	-2.408	267.70
3600.0	1.519	273.59	-2.779	270.84
3800.0	1.518	273.52	-2.983	270.11
4000.0	1.523	274.11	-2.911	266.41
4200.0	1.523	274.11	-3.369	267.33
4400.0	1.523	274.11	-3.369	267.33
4600.0	1.523	274.11	-3.369	267.33
4800.0	1.523	274.11	-3.369	267.33
5000.0	1.523	274.11	-3.369	267.33

ELECTRIC FIELD STRENGTH AS A FUNCTION OF TRANSMITTER-TERMINATOR DISTANCE(D)

GAMMA(DEG)= 90.0 PHI(DEG)= 90.0 TALT(KM) = 10.000 RALT(KM) = 10.000

	FIELD AT RHOMIN		FIELD AT RHOMAX	
D	EZ(DB)	EZ(ANG)	EZ(DB)	EZ(ANG)
-2000.0	28.928	134.32	25.824	173.24
-1800.0	28.928	134.32	25.824	173.24
-1600.0	28.928	134.32	25.824	173.24
-1400.0	28.928	134.32	25.824	173.24
-1200.0	28.928	134.32	25.824	173.24
-1000.0	28.928	134.32	25.824	173.24
-800.0	28.760	134.45	25.789	173.89
-600.0	29.573	127.05	24.895	175.62
-400.0	29.078	144.10	23.027	163.41
-200.0	25.437	155.31	23.537	120.66
.0	25.525	166.83	24.309	130.84
200.0	23.255	177.07	23.173	146.50
400.0	18.773	182.93	21.757	158.58
600.0	9.300	184.76	19.220	163.77
800.0	4.673	23.07	14.365	163.61
1000.0	13.123	26.28	4.228	144.42
1200.0	16.022	34.47	4.960	27.50
1400.0	16.745	42.03	10.997	22.53
1600.0	16.587	50.85	13.444	26.96
1800.0	15.691	55.72	13.924	33.64
2000.0	13.478	55.91	13.743	40.25
2200.0	9.621	52.54	12.761	42.36
2400.0	2.747	49.85	10.513	40.96
2600.0	-4.523	77.26	6.562	38.14
2800.0	-12.053	84.66	-.611	47.74
3000.0	-26.259	218.39	-5.303	86.15
3200.0	-9.125	271.03	-10.786	124.06
3400.0	-5.039	257.53	-12.922	188.34
3600.0	-3.973	258.64	-7.413	228.30
3800.0	-3.187	256.87	-4.791	230.56
4000.0	-3.201	253.11	-4.387	233.96
4200.0	-3.201	253.11	-3.534	228.53
4400.0	-3.201	253.11	-3.534	228.53
4600.0	-3.201	253.11	-3.534	228.53
4800.0	-3.201	253.11	-3.534	228.53
5000.0	-3.201	253.11	-3.534	228.53

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NAME
 &DATUM
 ICOMP=2,
  &END
 START
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ELECTRIC FIELD STRENGTH AS A FUNCTION OF TRANSMITTER-TERMINATOR DISTANCE(D)

GAMMA(DEG)= .0 PHI(DEG)= .0 TALT(KM) = 10.000 RALT(KM) = 10.000

	FIELD AT RHOMIN		FIELD AT RHOMAX	
D	EX(DB)	EX(ANG)	EX(DB)	EX(ANG)
-2000.0	12.942	129.62	15.437	215.89
-1800.0	12.942	129.62	15.437	215.89
-1600.0	12.942	129.62	15.437	215.89
-1400.0	12.942	129.62	15.437	215.89
-1200.0	12.942	129.62	15.437	215.89
-1000.0	12.942	129.62	15.437	215.89
-800.0	12.970	127.89	15.297	216.06
-600.0	13.350	130.93	15.065	218.12
-400.0	13.068	167.68	12.028	221.36
-200.0	1.805	154.20	3.485	196.33
.0	-8.690	163.69	-2.029	175.99
200.0	.063	184.67	-3.637	105.19
400.0	-.925	185.76	-4.269	119.69
600.0	-3.342	207.15	.793	135.56
800.0	-13.655	345.80	.275	133.14
1000.0	-3.387	312.79	.561	119.32
1200.0	-3.528	270.41	-5.959	86.22
1400.0	1.415	255.79	-11.460	202.11
1600.0	-2.558	225.04	-5.522	228.81
1800.0	-2.779	358.88	.321	240.71
2000.0	1.288	329.71	-5.386	278.88
2200.0	3.266	339.49	2.248	321.75
2400.0	-.315	325.54	-.025	324.72
2600.0	.371	63.37	.304	321.74
2800.0	2.486	52.44	-7.235	315.07
3000.0	2.686	58.73	2.013	12.50
3200.0	-1.213	48.45	.718	6.83
3400.0	2.483	80.01	1.462	43.18
3600.0	2.110	77.92	-5.328	31.93
3800.0	-.435	86.68	-2.321	71.98
4000.0	1.523	94.11	-5.509	57.99
4200.0	1.523	94.11	-3.369	87.33
4400.0	1.523	94.11	-3.369	87.33
4600.0	1.523	94.11	-3.369	87.33
4800.0	1.523	94.11	-3.369	87.33
5000.0	1.523	94.11	-3.369	87.33

ELECTRIC FIELD STRENGTH AS A FUNCTION OF TRANSMITTER-TERMINATOR DISTANCE(D)

GAMMA(DEG)= .0 PHI(DEG)= 90.0 TALT(KM) = 10.000 RALT(KM) = 10.000

	FIELD AT RHOMIN		FIELD AT RHOMAX	
D	EX(DB)	EX(ANG)	EX(DB)	EX(ANG)
-2000.0	12.942	129.62	15.437	215.89
-1800.0	12.942	129.62	15.437	215.89
-1600.0	12.942	129.62	15.437	215.89
-1400.0	12.942	129.62	15.437	215.89
-1200.0	12.942	129.62	15.437	215.89
-1000.0	12.942	129.62	15.437	215.89
-800.0	12.970	127.89	15.297	216.06
-600.0	13.350	130.93	15.065	218.12
-400.0	13.068	167.68	12.028	221.36
-200.0	1.805	154.20	3.485	196.33
.0	-8.690	163.69	-2.029	175.99
200.0	.063	184.67	-3.637	105.19
400.0	-.925	185.76	-4.269	119.69
600.0	-3.342	207.15	.793	135.56
800.0	-13.655	345.80	.275	133.14
1000.0	-3.387	312.79	.561	119.32
1200.0	-3.528	270.41	-5.959	86.22
1400.0	1.415	255.79	-11.460	202.11
1600.0	-2.558	225.04	-5.522	228.81
1800.0	-2.779	358.88	.321	240.71
2000.0	1.288	329.71	-5.386	278.88
2200.0	3.266	339.49	2.248	321.75
2400.0	-.315	325.54	-.025	324.72
2600.0	.371	63.37	.304	321.74
2800.0	2.486	52.44	-7.235	315.07
3000.0	2.686	58.73	2.013	12.50
3200.0	-1.213	48.45	.718	6.83
3400.0	2.483	80.01	1.462	43.18
3600.0	2.110	77.92	-5.328	31.93
3800.0	-.435	86.68	-2.321	71.98
4000.0	1.523	94.11	-5.509	57.99
4200.0	1.523	94.11	-3.369	87.33
4400.0	1.523	94.11	-3.369	87.33
4600.0	1.523	94.11	-3.369	87.33
4800.0	1.523	94.11	-3.369	87.33
5000.0	1.523	94.11	-3.369	87.33

ELECTRIC FIELD STRENGTH AS A FUNCTION OF TRANSMITTER-TERMINATOR DISTANCE(D)

GAMMA(DEG)= 90.0 PHI(DEG)= .0 TALT(KM) = 10.000 RALT(KM) = 10.000

	FIELD AT RHOMIN		FIELD AT RHOMAX	
D	EX(DB)	EX(ANG)	EX(DB)	EX(ANG)
-2000.0	.195	350.91	1.059	131.11
-1800.0	.195	350.91	1.059	131.11
-1600.0	.195	350.91	1.059	131.11
-1400.0	.195	350.91	1.059	131.11
-1200.0	.195	350.91	1.059	131.11
-1000.0	.195	350.91	1.059	131.11
-800.0	-1.230	356.13	1.914	127.77
-600.0	.599	340.28	.977	152.97
-400.0	-3.023	97.69	-3.961	167.38
-200.0	-27.385	167.93	-19.234	157.19
.0	-27.255	235.77	-20.675	172.13
200.0	-25.756	252.28	-29.176	197.74
400.0	-24.474	259.27	-32.680	280.16
600.0	-21.032	261.03	-32.954	268.65
800.0	-22.496	263.25	-29.835	291.71
1000.0	-24.743	296.78	-26.037	300.86
1200.0	-28.438	327.88	-27.247	327.18
1400.0	-36.546	34.80	-28.549	344.53
1600.0	-30.821	130.77	-35.235	352.21
1800.0	-28.651	118.96	-37.957	251.06
2000.0	-36.686	108.90	-34.968	205.88
2200.0	-31.507	64.60	-45.181	19.97
2400.0	-31.243	42.47	-43.521	329.10
2600.0	-35.269	121.76	-39.170	29.87
2800.0	-34.797	113.50	-42.788	47.38
3000.0	-36.196	95.46	-34.549	92.84
3200.0	-33.755	74.01	-35.429	80.22
3400.0	-31.991	61.12	-31.823	91.47
3600.0	-31.290	57.94	-33.116	90.90
3800.0	-31.481	55.32	-30.176	100.96
4000.0	-30.743	58.86	-31.367	92.78
4200.0	-30.743	58.86	-29.765	106.11
4400.0	-30.743	58.86	-29.765	106.11
4600.0	-30.743	58.86	-29.765	106.11
4800.0	-30.743	58.86	-29.765	106.11
5000.0	-30.743	58.86	-29.765	106.11

ELECTRIC FIELD STRENGTH AS A FUNCTION OF TRANSMITTER-TERMINATOR DISTANCE(D)

GAMMA(DEG)= 90.0 PHI(DEG)= 90.0 TALT(KM) = 10.000 RALT(KM) = 10.000

	FIELD AT RHOMIN		FIELD AT RHOMAX	
D	EX(DB)	EX(ANG)	EX(DB)	EX(ANG)
-2000.0	-20.300	201.59	11.050	290.93
-1800.0	-20.300	201.59	11.050	290.93
-1600.0	-20.300	201.59	11.050	290.93
-1400.0	-20.300	201.59	11.050	290.93
-1200.0	-20.300	201.59	11.050	290.93
-1000.0	-20.300	201.59	11.050	290.93
-800.0	-13.616	223.04	12.131	289.01
-600.0	1.204	198.97	9.353	311.75
-400.0	-6.100	229.70	3.942	307.02
-200.0	-6.261	54.87	-6.402	355.32
.0	-8.182	65.61	-6.879	24.82
200.0	-11.505	138.46	-7.498	45.62
400.0	-7.115	166.85	-12.984	69.50
600.0	-6.977	179.38	-12.501	144.05
800.0	-8.489	182.78	-9.290	161.16
1000.0	-10.821	217.41	-8.984	174.49
1200.0	-11.995	227.92	-11.972	180.10
1400.0	-15.398	272.65	-12.805	208.46
1600.0	-19.057	280.61	-16.061	212.35
1800.0	-33.932	357.53	-17.885	259.62
2000.0	-18.129	52.27	-21.925	281.10
2200.0	-15.355	58.84	-29.236	354.31
2400.0	-16.044	43.62	-22.271	26.59
2600.0	-25.823	218.37	-18.473	37.35
2800.0	-26.385	167.84	-17.782	20.63
3000.0	-34.014	160.22	-22.787	97.10
3200.0	-24.964	95.84	-23.065	91.38
3400.0	-40.105	110.31	-34.675	157.49
3600.0	-38.198	154.11	-29.608	81.02
3800.0	-35.298	139.65	-41.342	42.04
4000.0	-35.584	158.49	-37.892	110.41
4200.0	-35.584	158.49	-44.579	146.60
4400.0	-35.584	158.49	-44.579	146.60
4600.0	-35.584	158.49	-44.579	146.60
4800.0	-35.584	158.49	-44.579	146.60
5000.0	-35.584	158.49	-44.579	146.60

NAME
&DATUM
ICOMP=3,
&END
START

ELECTRIC FIELD STRENGTH AS A FUNCTION OF TRANSMITTER-TERMINATOR DISTANCE(D)

GAMMA(DEG)= .0 PHI(DEG)= .0 TALT(KM) = 10.000 RALT(KM) = 10.000

	FIELD AT RHOMIN		FIELD AT RHOMAX	
D	EY(DB)	EY(ANG)	EY(DB)	EY(ANG)
-2000.0	28.462	127.15	25.076	165.33
-1800.0	28.462	127.15	25.076	165.33
-1600.0	28.462	127.15	25.076	165.33
-1400.0	28.462	127.15	25.076	165.33
-1200.0	28.462	127.15	25.076	165.33
-1000.0	28.462	127.15	25.076	165.33
-800.0	28.419	127.06	24.957	165.28
-600.0	28.636	127.76	24.283	164.97
-400.0	27.345	126.33	22.238	152.32
-200.0	25.867	132.03	22.200	112.50
.0	26.449	155.13	23.320	108.54
200.0	26.787	173.76	22.433	117.68
400.0	24.021	197.26	20.866	140.75
600.0	19.692	246.01	16.052	146.63
800.0	20.415	303.42	5.049	63.46
1000.0	20.643	325.64	14.453	20.05
1200.0	20.511	336.59	13.601	10.48
1400.0	19.186	326.73	8.618	7.48
1600.0	18.736	331.72	11.792	307.57
1800.0	19.154	332.08	14.819	277.75
2000.0	17.131	321.78	16.845	282.73
2200.0	14.576	297.31	18.224	279.33
2400.0	9.314	248.62	17.301	272.36
2600.0	4.674	20.72	15.901	258.25
2800.0	4.694	345.96	8.729	238.16
3000.0	-2.583	3.12	10.483	309.05
3200.0	1.775	209.93	6.714	295.69
3400.0	-.367	126.41	.225	4.89
3600.0	-2.687	150.58	.175	159.70
3800.0	.716	164.35	1.050	116.83
4000.0	1.785	163.01	.099	137.13
4200.0	1.785	163.01	1.509	138.72
4400.0	1.785	163.01	1.509	138.72
4600.0	1.785	163.01	1.509	138.72
4800.0	1.785	163.01	1.509	138.72
5000.0	1.785	163.01	1.509	138.72

ELECTRIC FIELD STRENGTH AS A FUNCTION OF TRANSMITTER-TERMINATOR DISTANCE(D)

GAMMA(DEG)= .0 PHI(DEG)= 90.0 TALT(KM) = 10.000 RALT(KM) = 10.000

	FIELD AT RHOMIN		FIELD AT RHOMAX	
D	EY(DB)	EY(ANG)	EY(DB)	EY(ANG)
-2000.0	28.462	127.15	25.076	165.33
-1800.0	28.462	127.15	25.076	165.33
-1600.0	28.462	127.15	25.076	165.33
-1400.0	28.462	127.15	25.076	165.33
-1200.0	28.462	127.15	25.076	165.33
-1000.0	28.462	127.15	25.076	165.33
-800.0	28.419	127.06	24.957	165.28
-600.0	28.636	127.76	24.283	164.97
-400.0	27.345	126.33	22.238	152.32
-200.0	25.867	132.03	22.200	112.50
.0	26.449	155.13	23.320	108.54
200.0	26.787	173.76	22.433	117.68
400.0	24.021	197.26	20.866	140.75
600.0	19.692	246.01	16.052	146.63
800.0	20.415	303.42	5.049	63.46
1000.0	20.643	325.64	14.453	20.05
1200.0	20.511	336.59	13.601	10.48
1400.0	19.186	326.73	8.618	7.48
1600.0	18.736	331.72	11.792	307.57
1800.0	19.154	332.08	14.819	277.75
2000.0	17.131	321.78	16.845	282.73
2200.0	14.576	297.31	18.224	279.33
2400.0	9.314	248.62	17.301	272.36
2600.0	4.674	20.72	15.901	258.25
2800.0	4.694	345.96	8.729	238.16
3000.0	-2.583	3.12	10.483	309.05
3200.0	1.775	209.93	6.714	295.69
3400.0	-.367	126.41	.225	4.89
3600.0	-2.687	150.58	.175	159.70
3800.0	.716	164.35	1.050	116.83
4000.0	1.785	163.01	.099	137.13
4200.0	1.785	163.01	1.509	138.72
4400.0	1.785	163.01	1.509	138.72
4600.0	1.785	163.01	1.509	138.72
4800.0	1.785	163.01	1.509	138.72
5000.0	1.785	163.01	1.509	138.72

ELECTRIC FIELD STRENGTH AS A FUNCTION OF TRANSMITTER-TERMINATOR DISTANCE(D)

GAMMA(DEG)= 90.0 PHI(DEG)= .0 TALT(KM) = 10.000 RALT(KM) = 10.000

	FIELD AT RHOMIN		FIELD AT RHOMAX	
D	EY(DB)	EY(ANG)	EY(DB)	EY(ANG)
-2000.0	-15.262	24.89	10.274	105.96
-1800.0	-15.262	24.89	10.274	105.96
-1600.0	-15.262	24.89	10.274	105.96
-1400.0	-15.262	24.89	10.274	105.96
-1200.0	-15.262	24.89	10.274	105.96
-1000.0	-15.262	24.89	10.274	105.96
-800.0	-17.253	335.79	11.383	103.92
-600.0	-2.541	22.57	9.308	126.66
-400.0	.342	30.49	5.380	132.44
-200.0	-13.435	145.65	-5.348	144.22
.0	-4.881	145.56	-6.048	152.84
200.0	-.387	160.63	-6.876	165.99
400.0	1.202	181.68	-3.748	185.97
600.0	.727	210.10	-1.690	206.98
800.0	-1.390	243.25	-2.008	234.21
1000.0	-3.019	282.41	-3.267	269.56
1200.0	-5.202	314.16	-4.665	308.67
1400.0	-7.070	346.29	-5.786	340.23
1600.0	-7.968	9.89	-7.662	2.30
1800.0	-7.300	24.63	-10.422	20.51
2000.0	-7.651	30.83	-11.914	36.38
2200.0	-9.455	38.38	-12.541	46.05
2400.0	-15.205	50.72	-14.879	59.97
2600.0	-17.983	115.12	-19.907	81.96
2800.0	-22.536	138.00	-24.170	140.74
3000.0	-29.084	187.00	-30.241	158.70
3200.0	-31.432	245.52	-31.292	248.12
3400.0	-30.479	263.40	-37.922	305.28
3600.0	-29.845	264.06	-35.367	259.19
3800.0	-30.103	255.49	-48.673	326.32
4000.0	-30.600	250.16	-39.565	285.55
4200.0	-30.600	250.16	-39.998	237.42
4400.0	-30.600	250.16	-39.998	237.42
4600.0	-30.600	250.16	-39.998	237.42
4800.0	-30.600	250.16	-39.998	237.42
5000.0	-30.600	250.16	-39.998	237.42

ELECTRIC FIELD STRENGTH AS A FUNCTION OF TRANSMITTER-TERMINATOR DISTANCE(D)

GAMMA(DEG)= 90.0 PHI(DEG)= 90.0 TALT(KM) = 10.000 RALT(KM) = 10.000

	FIELD AT RHOMIN		FIELD AT RHOMAX	
D	EY(DB)	EY(ANG)	EY(DB)	EY(ANG)
-2000.0	29.535	354.69	30.007	71.18
-1800.0	29.535	354.69	30.007	71.18
-1600.0	29.535	354.69	30.007	71.18
-1400.0	29.535	354.69	30.007	71.18
-1200.0	29.535	354.69	30.007	71.18
-1000.0	29.535	354.69	30.007	71.18
-800.0	28.963	357.39	29.999	69.64
-600.0	29.670	345.92	30.294	79.73
-400.0	26.560	76.02	27.138	86.05
-200.0	2.175	158.38	12.521	97.25
.0	8.330	273.89	8.534	113.70
200.0	13.933	288.27	-3.651	182.87
400.0	15.016	291.57	7.806	273.23
600.0	13.077	304.94	11.914	283.09
800.0	10.934	324.04	11.641	285.77
1000.0	7.205	334.48	9.385	300.94
1200.0	-8.528	88.03	7.099	317.81
1400.0	6.662	126.41	1.471	320.86
1600.0	10.467	131.01	-3.055	116.96
1800.0	10.097	139.05	5.270	124.50
2000.0	10.394	152.66	7.585	124.74
2200.0	8.086	155.60	6.882	137.59
2400.0	2.566	157.69	7.231	143.80
2600.0	-7.566	230.79	4.405	144.85
2800.0	-4.359	326.34	-3.199	138.92
3000.0	2.159	355.51	-17.874	240.72
3200.0	4.350	12.61	-5.877	335.39
3400.0	7.293	13.54	.309	351.50
3600.0	7.268	14.20	3.014	5.10
3800.0	7.357	18.86	4.837	5.98
4000.0	8.317	19.38	4.114	6.59
4200.0	8.317	19.38	5.906	10.93
4400.0	8.317	19.38	5.906	10.93
4600.0	8.317	19.38	5.906	10.93
4800.0	8.317	19.38	5.906	10.93
5000.0	8.317	19.38	5.906	10.93

QUIT

END OF JOB

APPENDIX 1

FORTRAN LISTING OF THE GRNDMC COMPUTER PROGRAM

```
MORFITT*GRNDMCA(1).MAIN
      C  ORIGINAL DNA PROGRAM MODIFIED TO HANDLE NEGATIVE XVALS           00000000
         IMPLICIT REAL *8(A-H,O-Z)                                        00000020
         COMMON/PLOT C/FRQP,RHOMNP,RHOMXP
         COMMON/FIRST C/ IFIRST
         COMMON/AXISM C/XTIC,YTIC,NTICX,NTICY
         COMMON/ITXRX C/ITXRX
         COMMON/TYPPLT/IPLTOP                                             00000800
         COMMON/INT C/INTFLG,IPRNTA
         COMMON/TERM/NT,NTR
         COMMON/MMODS C/ MAXMDS
         COMMON/MCINPT/               FOFR(20  ),XVAL(50),FREQ,
       $   XTRA(20  ),TOPHT(50),RHOMAX,RHOMIN,DELRHO,DELTAX,
       $   EPSR,SIGMA,NRSLAB,NRMODE,NTMAX,PRMODE,NTRMDS
         COMMON/MCSTOR/A(20,20 ),S(20  ),C(20  ),KVRAOT,KVRATT,AVRKOT,    00004550
       &   AVRKTT,NTHSQ,CONST,OMEGA,WAVENO                                00000090
         COMMON/MCPLOT/R(402),DB(402),ANG(402),IDPLOT(10),ISUB,JPLOT,
       $  NAPLOT,NPPLOT
         COMMON/XPLOT/XMIN,XINC,YMIN,YINC,SIZEX,SIZEY                     00000110
         COMMON/PSPLOT/PHSMIN,PHSINC,SIZEP,PTIC,NTICP
         DIMENSION BUFFER(2000)                                           00000120
         DIMENSION BCD(20)
         COMPLEX*16 STHTA,THETAH,STHTAH(20)
         COMPLEX*16 ZERO/(0.0D0,0.0D0)/,ONE/(1.0D0,0.0D0)/
         COMPLEX*16 THETA,A,S,C,FOFR,IM
         COMPLEX*16 XTRA                                                  00000160
         COMPLEX*16 TP(20),RATIO(4),TMP1,TMP2,TMP3,TMP4
         REAL*8 NTHSQ
         REAL*8 KVRAOT,KVRATT                                             00000220
         REAL*4 SIZEP,PHSMIN,PHSINC,PTIC
         REAL*4 FACT
         REAL*4 R,DB,ANG,XMIN,XINC,YMIN,YINC,SIZEX,SIZEY                  00000140
         REAL*4 XTIC,YTIC
         CHARACTER*4 BCD,NAME,EXEC,INPT,QUIT
         INTEGER PRMODE,RCDOPT,CNVSCF
      C
         NAMELIST/DATUM/TOPHT,RHOMAX,NPRINT,RCDOPT,H,IH,
       $         DELRHO,INTFLG,       IPLTOP,IPRNTA,ITXRX,
       &   RHOMIN,DELTAX,NTMAX,XVAL,
       $     FACT,NAPLOT,NPPLOT,
       $     PHSMIN,PHSINC,SIZEP,PTIC,NTICP,
       $   XMIN,XINC,YMIN,YINC,SIZEX,SIZEY,XTIC,YTIC,NTICX,NTICY
      C
         DATA NAME/4HNAME/,INPT/4HDATA/,EXEC/4HSTAR/,QUIT/4HQUIT/
         DATA DTR/0.01745329252D0/
         DATA TWOPI/6.283185D0/,VELITE/2.997928D5/,ALPHA/3.14D-4/,        00000190
       $  DEGRAD/1.745329D-2/,IM/(0.0D0,1.0D0)/                           00000200
      C
      C     'FF1SQ' IS THE WRONSKIAN OF THE VERTICAL HEIGHT GAIN TERM
         DATA FF1SQ/-2.1242929606537200/
```

```
C
C-----------------------------------------------------------------------
      FACT=1.0
      SIZEP=8.0
      PHSMIN=0.0
      PHSINC=90.0
      NTICP=1
      PTIC=2.0
      SIZEX=10.0
      SIZEY=8.0
      XMIN=0.0
      YMIN=0.0
      XINC=1000.0
      YINC=10.0
      XTIC=1.0
      YTIC=1.0
      NTICX=1
      NTICY=1
      IH=1
      H=50.0D0
      CNVSCF=0
      RCDOPT=0
      JPLOT=0
      NAPLOT=1
      NPPLOT=0
      INTFLG=0                                                          00000280
      MAXMDS = 20
      MXSLAB=50
      IFIRST =1
      NPRINT=1
      IPRNTA=0
      DELTAX=0.0
      NTMAX=1
      IPLTOP=0
C-----------------------------------------------------------------------
C
      DO 2 J=1,MXSLAB
    2 TOPHT(J)=0.0D0
C
C                                                                       00000270
C-----------------------------------------------------------------------
      PRINT 199
   10 PRINT 200
      READ(5,201,END=999) BCD
   11 PRINT 202,BCD
      IF(BCD(1) .EQ. NAME) GO TO 12
      IF(BCD(1) .EQ. INPT) GO TO 20
      IF(BCD(1) .EQ. EXEC) GO TO 30
      IF(BCD(1) .EQ. QUIT) GO TO 999
      GO TO 910
```

```
C-----------------------------------------------------------------------
C
C       READ NAMELIST
    12 READ(5,201,END=999) BCD
       IF(SUBSTR(BCD(1),1,1) .NE. ' ') GO TO 13
       WRITE(30,201) BCD
       WRITE(6,202) BCD
       GO TO 12
    13 REWIND 30
       DO 15 L = 1,MXSLAB
       XVAL(L) = 0.0D0
    15 TOPHT(L)=0.0D0
C
       CALL CHK$OF
       READ(30,DATUM)
       CALL CHK$ON
       IF(IPLTOP .LT. 1) GO TO 909
C
       IF(IPLTOP .LT. 2) GO TO 16
       NTMAX=1
       DELTAX=0.0
       RHOMIN=DELRHO
    16 CONTINUE
C
       IF(NAPLOT .EQ. 1 .OR. NPPLOT .EQ. 1) JPLOT=1
       IF(JPLOT     .NE. 0 .AND. IFIRST .NE. 0)CALL PLOTS(BUFFER,2000,15)00000480
       IF(JPLOT     .NE. 0 .AND. IFIRST .NE. 0)CALL PLOT(0.0,-11.0,-3)
       IF(JPLOT     .NE. 0 .AND. IFIRST .NE. 0)CALL FACTOR(FACT)
       CAPK=(1.0D0-0.5D0*ALPHA*H)
       NT = 1                                                           00000490
       REWIND 30
       GO TO 11
C
C-----------------------------------------------------------------------
C
C      READ NPUNCH=1 DATA
C
    20 READ(5,203,END=915) IDPLOT
       PRINT 204,IDPLOT
       RHO=-1.0
       ISLAB=0
C
C         READ IN A SLAB FROM INPUT DATA
C
    21 READ(5,1020,END=915) RR,FF,AA,CC,BB,SS,EE,TH
       ISLAB=ISLAB+1
       IF(RR .NE. 40.  .AND. SS .EQ. 0.) GO TO 21
       IF(RR .EQ. 40) GO TO 25
C-----------------------------------------------------------------------
C
```

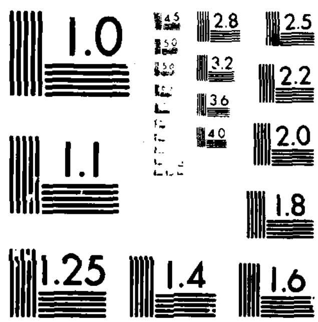
```
C        OPTION TO USE R-CARDS FOR 'XVAL(ISLAB)' VALUES
C          (FOR 'IPLTOP=2' OPTION ONLY)
      IF(RCDOPT .EQ. 0) GO TO 28
      IF(IPLTOP .EQ. 2) XVAL(ISLAB) = RR*1000.0
   28 CONTINUE
C-----------------------------------------------------------------------
C
      NTHSQ=1.0+ALPHA*TOPHT(ISLAB)
      IF(TOPHT(ISLAB) .EQ. 0.0D0) NTHSQ=1.0D0+ALPHA*TH
      BB=BB*10000.
      PRINT 1022,ISLAB,RR,FF,AA,CC,BB,SS,EE,TH
      IF(NPRINT .GE. 3) PRINT 1024
      FREQ=FF
      IF(ISLAB .NE. 1) GO TO 22
      WAVE NO = TWO PI*1000.0*FREQ/VELITE                               00000500
      CONST = 0.03248*WAVE NO/DSQRT(FREQ)                               00000510
      OMEGA = TWO PI*FREQ*1000.                                         00000520
      KVRAOT = DEXP(DLOG(WAVE NO/ALPHA)/3.)                             00000530
      KVRATT = KVRAOT**2                                                00000540
      AVRKOT = 1./KVRAOT                                                00000550
      AVRKTT = AVRKOT**2*0.5                                            00000560
   22 CONTINUE
      IF(RHO .GT. RR) GO TO 912
      RHO=RR
      EPSR=EE
      SIGMA=SS
C
C-----------------------------------------------------------------------
C         READ IN T-CARDS FOR EACH SLAB
C
      NM=0
   23 READ(5,1023,END=915) INDX1,TR1,TI1,ITRM1,TMP1,TMP2
      IF(TR1 .EQ. 0.) GO TO 24
      READ(5,1023,END=915) INDX2,TR2,TI2,ITRM2,TMP3,TMP4
      IF(NM .EQ. 20) GO TO 233
      IF(CDABS(TMP1) .EQ. 0.0D0) GO TO 233
      IF(TR1 .NE. TR2 .OR. TI1 .NE. TI2) GO TO 234
      IF(ITRM1 .NE. ITRM2) GO TO 234
      IF(ITRM1 .EQ. 0) GO TO 911
      NM=NM+1
      IF(NPRINT .LT. 3) GO TO 230
      PRINT 1025,NM,INDX1,TR1,TI1,ITRM1,TMP1,TMP2,
     $                INDX2,TR2,TI2,ITRM2,TMP3,TMP4
  230 TP(NM)=DCMPLX(TR1,TI1)
      S(NM)=CDSIN(TP(NM)*DTR)
      C(NM)=CDCOS(TF(NM)*DTR)
      STHTA=S(NM)*CAPK
      THETAH=-IM*CDLOG(CDSQRT(1.0D0-STHTA**2)+IM*STHTA)
      STHTAH(NM)=CDSIN(THETAH)
      RATIO(2*INDX1-1)=TMP1
```

```
      RATIO(2*INDX1  )=TMP2
      RATIO(2*INDX2-1)=TMP3
      RATIO(2*INDX2  )=TMP4
      IF(ITRM1 .EQ. 2) GO TO 231
      FOFR(NM)=RATIO(3)/RATIO(1)
      GO TO 232
  231 FOFR(NM)=RATIO(2)/(RATIO(3)*RATIO(4))
  232 CONTINUE
      IF(IH .EQ. 0) STHTAH(NM)=S(NM)
      XTRA(NM)=RATIO(1)*FF1SQ*STHTAH(NM)**2
      GO TO 23
  233 IF(NPRINT .LT. 3) GO TO 23
  234 PRINT 1026, INDX1,TR1,TI1,ITRM1,TMP1,TMP2,
     $            INDX2,TR2,TI2,ITRM2,TMP3,TMP4
      IF(TR1 .NE. TR2 .OR. TI1 .NE. TI2) GO TO 916
      IF(ITRM1 .NE. ITRM2) GO TO 917
   24 IF(NPRINT .LT. 3) PRINT 1027,NM
      NRMODE=NM
C
C-----------------------------------------------------------------------
C
C        WRITE SLAB INFORMATION ON TO UNIT 9
C
      WRITE(9) ISLAB,S,C,TP,XTRA,FOFR,NRMODE,NTHSQ,SIGMA,EPSR
C
C-----------------------------------------------------------------------
C
C        READ IN A NEW SLAB FROM FROM INPUT DATA
C
      GO TO 21
C-----------------------------------------------------------------------
C
   25 NRSLAB = ISLAB-1
      IF(NRSLAB .LE. 1) GO TO 914
      GO TO 10
C-----------------------------------------------------------------------
C
   30 CONTINUE
C
C        ALL SLABS HAVE BEEN READ IN
C
      REWIND 9
      REWIND 4
C
C-----------------------------------------------------------------------
C     IF THE CONVERSION COEFFICIENTS HAVE ALREADY BEEN COMPUTED
C     ------SKIP TO STATEMENT 118-----
      IF(CNVSCF .GT. 0) GO TO 118
C
C-----------------------------------------------------------------------
```

AD-A082 695 NAVAL OCEAN SYSTEMS CENTER SAN DIEGO CA F/G 20/14
'SIMPLIFIED' VLF/LF MODE CONVERSION COMPUTER PROGRAMS: GRNDMC A--ETC(U)
JAN 80 D G MORFITT MIPR-80-563
UNCLASSIFIED NOSC/TR-514 NL

2 OF 2

END
DATE FILMED
5-80
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

```
C         COMPUTE THE CONVERSION COEFFICIENTS FOR EACH INPUT SLAB
C
      DO 555 M=1,NRSLAB
C
      READ (9) ISLAB,S,C,TP,XTRA,FOFR,NRMODE,NTHSQ,SIGMA,EPSR
C
      IFLG=1
      IF(M .EQ. 1) IFLG=0
      CALL HTINTL(IFLG, M,INTFLG)
  555 CONTINUE
C
C         CONVERSION COEFFICIENTS HAVE BEEN STORED ON UNIT 4
C
      REWIND 9
      REWIND 4
C-----------------------------------------------------------------------
C
C         IDENTIFY THE SLAB WHICH CONTAINS THE TRANSMITTER (I.E. NTR)
C
  118 CONTINUE
C
      IF(XVAL(2) .GE. 0.0) GO TO 111
      DO 113 L=3,NRSLAB
      IF(XVAL(L) .GE. 0.0) GO TO 114
  113 CONTINUE
      NTR = NRSLAB
      GO TO 120
  114 NTR=L-1
  115 CONTINUE
      GO TO 120
  111 NTR = 1
  120 CONTINUE
C
      IF(ITXRX .LT. 1) GO TO 804
      PRINT 800,NTR
  800 FORMAT('0',' THE TRANSMITTER IS IN SLAB NO. ',I5/)
      PRINT 801
  801 FORMAT(' ',10X,' XVAL(I) = ')
      DO 802  I = 1,NRSLAB
  802 PRINT 803,XVAL(I)
  803 FORMAT(20X,F10.3/)
  804 CONTINUE
C
      FRQP=FREQ
      RHOMNP=RHOMIN
      RHOMXP=RHOMAX
C
C-----------------------------------------------------------------------
C
91    IF(IPLTOP .EQ. 1) CALL MCFLD                                     00000940
```

```
      IF(IPLTOP .EQ. 2) CALL MCFLD2                                     00000950
C
      NT = NT+1                                                         00000960
      DO 106 ME=1,NRSLAB
106   XVAL(ME) = XVAL(ME)+DELTAX                                        00000980
C
C-----------------------------------------------------------------------
C
C     CHECK TO SEE IF A SLAB BOUNDRY HAS MOVED PAST THE TRANSMITTER
C
      IF(XVAL(NTR) .GE. 0. .AND. NT .LE. NTMAX) GO TO 118               00000990
      IF(NT .LE. NTMAX) GO TO 91                                        00001000
C
      IFIRST =0
      CNVSCF=1
      REWIND 4
      REWIND 9
      GO TO 10
C-----------------------------------------------------------------------
C
C     ERROR EXITS
  909 PRINT 1909
  910 PRINT 1910
      GO TO 999
  911 PRINT 1911
      GO TO 999
  912 PRINT 1912
      GO TO 999
  914 PRINT 1914
      GO TO 999
  915 PRINT 1915
      GO TO 999
  916 PRINT 1916
      GO TO 999
  917 PRINT 1917
C
 1909 FORMAT('0','*****  FIELD STRENGTH OPTION (IPLTOP) WAS NOT SET ')
 1910 FORMAT('0*****  ERROR IN CONTROL CARD')
 1911 FORMAT('0*****  THIS DATA DECK IS MISSING THE FOFR FLAG IN 20')
 1912 FORMAT('0*****  XVALS OUT OF ORDER')
 1914 FORMAT('0*****  NUMBER OF SLABS LESS THAN 2')
 1915 FORMAT('0*****  END OF DATA SET ON UNIT 5')
 1916 FORMAT('0*****  ERROR IN DATA SEQUENCE')
 1917 FORMAT('0*****  ITERM FLAG INCONSISTENT')
C
  199 FORMAT('1')
  200 FORMAT(' ')
  201 FORMAT(20A4)
  202 FORMAT(' ',20A4)
  203 FORMAT(10A4)
```

```
  204 FORMAT(' ',10A4)
 1001 FORMAT('0END OF JOB')
 1020 FORMAT(1X,F7.0,3(2X,F8.0),2(2X,E10.0),2(2X,E5.0))
 1022 FORMAT('0SLAB ',I2,' R',F7.3,' F',F8.4,' A',F8.3,' C',F8.3,' M',
     $ F6.3,' S',1PE10.3,' E',0PF5.1,' T',F5.1)
 1023 FORMAT(I1,2F9.0,I1,4E15.0)
 1024 FORMAT(/11X,' M  ID     THETA''')
 1025 FORMAT(11X,I2,3X,I1,0P2F10.2,I2,2(1X,1P2E16.8)/
     $    16X,          I1,0P2F10.2,I2,2(1X,1P2E16.8))
 1026 FORMAT(16X,       I1,0P2F10.2,I2,2(1X,1P2E16.8)/
     $    16X,          I1,0P2F10.2,I2,2(1X,1P2E16.8))
 1027 FORMAT('+',80X,' MODES',I3)
  999 CONTINUE
      REWIND 9
      REWIND 4
      PRINT 1001
      IF(JPLOT .EQ. 1) CALL PLOT(0.,0.,999)
      STOP
      END

@PRT,S GRNDMCA.HTINTL
```

```
MORFITT*GRNDMCA(1).HTINTL
      SUBROUTINE HTINTL(IFLG,M,INTFLG)
      IMPLICIT REAL *8(A-H,O-Z)                                          00001460
      COMMON/NPRNT C/NPRINT
      COMMON/MMODS C/ MAXMDS
      COMMON/MCINPT/            FOFR(20  ),XVAL(50),FREQ,
     $   XTRA(20  ),TOPHT(50),RHOMAX,RHOMIN,DELRHO,DELTAX,
     $   EPSR,SIGMA,NRSLAB,NRMODE,NTMAX,PRMODE,NTRMDS
      COMMON/MCSTOR/A(20,20 ),S(20  ),C(20  ),KVRAOT,KVRATT,AVRKOT,      00004550
     &   AVRKTT,NTHSQ,CONST,OMEGA,WAVENO                                 00001510
      COMPLEX*16 INORM(20,20)
      COMPLEX*16 PTHA,H1TA,H2TA,H1PRTA,H2PRTA,HYTHA(20),EYTHA(20),
     $ HYTHPA(20),EYTHPA(20)
      COMPLEX*16 THETA,FOFR,A,S,C,SSQ,CSQ,IM/(0.0D0,1.0D0)/,NGSQ,        00001550
     &   SQROOT,RTIORT,PO,PTH,H10,H20,H1PRM0,H2PRM0,CAPH10,CAPH20,       00001560
     & A1ST,A2ND,A3RD,A4TH,DEN12,DEN34,DENMF,NURMF,                      00001570
     &   H1T,H2T,H1PRMT,H2PRMT,HYTH(20),EYTH(20),HYTHPR(20),EYTHPR(20),
     &   HYOPR(20),EYOPR(20),EYO(20),MULT,FAC1,FAC2,NORM(20,20),PS(20),
     $   CAPI(20,20),PHYTH(20),PHYTHP(20),PEYTH(20),PEYTHP(20),
     $   PEYO(20),PEYOPR(20),PHYOPR(20),XTRA
      COMPLEX*16 ZERO/(0.0D0,0.0D0)/,ONE/(1.0D0,0.0D0)/
      REAL*8 NTHSQ,NTHSQP
      INTEGER PRMODE
      REAL*8 KVRAOT,KVRATT                                               00001620
      REAL * 4 ERR
      DATA EPSLNO/8.85434D-12/                                           00001630
C                                                                        00001640
C                                                                        00001650
      DO 5 K=1,MAXMDS
      DO 5 J=1,MAXMDS
    5 INORM(J,K)=ZERO
C-----------------------------------------------------------------------
C
      DO 100 K = 1, NRMODE                                               00001660
      SSQ = S(K)**2
      CSQ = C(K)**2
      NGSQ =    EPSR    -(IM*SIGMA   /OMEGA)/EPSLNO
      SQROOT = CDSQRT(NGSQ - SSQ)                                        00001700
      RSQR = SQROOT                                                      00001710
      IF(RSQR .LT. 0.) SQROOT=-SQROOT                                    00001720
      RTIORT = 1./NGSQ*SQROOT                                            00001730
      PO = KVRATT*CSQ                                                    00001740
      PTH = KVRATT*(NTHSQ   -SSQ)
      CALL MDHNKL(PO,H10,H20,H1PRM0,H2PRM0)                              00001760
      CAPH10 = H1PRM0 + AVRKTT*H10                                       00001770
      CAPH20 = H2PRM0 + AVRKTT*H20                                       00001780
      A1ST = CAPH20 - IM*RTIORT*KVRAOT*H20                               00001790
      A2ND = CAPH10 - IM*RTIORT*KVRAOT*H10                               00001800
      A3RD = H2PRM0 - IM*KVRAOT*SQROOT*H20                               00001810
      A4TH = H1PRM0 - IM*KVRAOT*SQROOT*H10                               00001820
```

```
      DEN12 = H20*A2ND - H10*A1ST                                       00001830
      DEN34 = H20*A4TH - H10*A3RD                                       00001840
      CALL MDHNKL(PTH,H1T,H2T,H1PRMT,H2PRMT)                            00001850
C
      HYTH(K) = (H2T*A2ND - H1T*A1ST)/DEN12                             00001860
      EYTH(K) = (H2T*A4TH - H1T*A3RD)/DEN34*FOFR(  K)                   00001870
      HYTHPR(K) = (H2PRMT*A2ND - H1PRMT*A1ST)/DEN12                     00001880
      EYTHPR(K) = (H2PRMT*A4TH - H1PRMT*A3RD)/DEN34*FOFR(  K)           00001890
      HYOPR(K) = (H2PRMO*A2ND - H1PRMO*A1ST)/DEN12                      00001900
      EYOPR(K) = (H2PRMO*A4TH - H1PRMO*A3RD)/DEN34*FOFR(  K)            00001910
C
      IF(IFLG .EQ. 0) GO TO 100                                         00001920
C-----------------------------------------------------------------------
C
C     NOT FIRST SLAB
C
      PTHA = KVRATT*(NTHSQP     -SSQ)
      CALL MDHNKL(PTHA,H1TA,H2TA,H1PRTA,H2PRTA)                         00001940
      HYTHA(K) = (H2TA*A2ND-H1TA*A1ST)/DEN12                            00001950
      EYTHA(K) = (H2TA*A4TH-H1TA*A3RD)/DEN34*FOFR(  K)                  00001
      HYTHPA(K) = (H2PRTA*A2ND-H1PRTA *A1ST)/DEN12                      00001970
      EYTHPA(K) = (H2PRTA*A4TH-H1PRTA*A3RD)/DEN34*FOFR(  K)             000019
C
  100 EYO(K) = FOFR(  K)
C
C-----------------------------------------------------------------------
C
C     COMPUTE NORM(J,K) FOR ALL SLABS
C
      IF(INTFLG .EQ. 1) PRINT 906,M                                     00002000
      DO 240 J = 1,NRMODE                                               00002010
      DO 240 K = 1,NRMODE                                               00002020
      IF(J .EQ. K) GO TO 120                                            00002030
      MULT = AVRKOT/((S(  J) - S(  K))*WAVENO)
      FAC1 = EYTH(K)*EYTHPR(J) - EYTH(J)*EYTHPR(K) + HYTH(K)*HYTHPR(J)  00002050
     $   -HYTH(J)*HYTHPR(K)                                             00002060
      FAC2 = -EYO(K)*EYOPR(J) + EYO(J)*EYOPR(K) - HYOPR(J) + HYOPR(K)   00002070
      NORM(  J,K) = MULT*(FAC1+FAC2)                                    00002080
      IF(INTFLG .EQ. 0) GO TO 240
      CALL MAGANG( NORM(J,K),AMAGG,ANGG)
      PRINT 908,M,J,K,NORM(J,K),AMAGG,ANGG
      GO TO 240
  120 MULT = 2.0*S(  J)*KVRAOT/WAVENO
      PTH = KVRATT*(NTHSQ    -S(  J)**2)
       PO = KVRATT*C(  J)**2
      FAC1 = EYTHPR(J)**2 + HYTHPR(J)**2 + PTH*(EYTH(J)**2 + HYTH(J)**2)00002140
      FAC2 = -EYOPR(J)**2 - HYOPR(J)**2 - PO*(EYO(J)**2 + 1.0)          00002150
      NORM(  J,K) = MULT*(FAC1+FAC2)                                    00002160
      IF(INTFLG .EQ. 0) GO TO 240
      CALL MAGANG( NORM(J,K),AMAGG,ANGG)
```

```
      PRINT 908,M,J,K,NORM(J,K),AMAGG,ANGG
  240 CONTINUE                                                          00002180
C-----------------------------------------------------------------------------
C
C     FOR FIRST SLAB ONLY
C
      IF (IFLG  .NE. 0) GO TO 500
      PRMODE = NRMODE
      DO 602 K   =1,NRMODE
      PS(K )   = S(K    )
      DO 602 J   =1,NRMODE
  602 INORM(J    ,K    )=ZERO
      GO TO 850
C
C-----------------------------------------------------------------------------
C
C     COMPUTE CAPI(K,J) AND INORM(K,J) FOR ALL SLABS
C     EXCEPT THE FIRST
C
  500 CONTINUE
      DO 400 K = 1, NRMODE
      DO 400 J = 1, PRMODE
      MULT = AVRKOT/((PS(J) - S(   K))*WAVENO)
      FAC1 = EYTHA(K)*PEYTHP(J)-PEYTH(J)*EYTHPA(K)                      00002230
     $+HYTHA(K)*PHYTHP(J)-PHYTH(J)*HYTHPA(K)                            00002240
      FAC2 = -EYO(K)*PEYOPR(J) + PEYO(J)*EYOPR(K) -PHYOPR(J) + HYOPR(K) 00002250
      CAPI(   K,J) = MULT*(FAC1+FAC2)                                   00002260
      IF(INTFLG .EQ. 0) GO TO 400
      CALL MAGANG( CAPI(K,J),AMAGG,ANGG)
      PRINT 910,M,K,J,CAPI(K,J),AMAGG,ANGG
  400 CONTINUE                                                          00002280
C
      INIT = 0
      DO 700 J = 1,PRMODE
      CALL CLINEQ(NORM ,CAPI (1,J),INORM(1,J  ),NRMODE,MAXMDS,INIT,ERR)
      INIT = 1
      IF(ABS(ERR) .GT. 0.01)   PRINT 701,ERR,J
  701 FORMAT('0','  ERR = ',F5.0,'           J = ',I3)
  700 CONTINUE
C
C-----------------------------------------------------------------------------
  850 CONTINUE
C
      WRITE(4) M,INORM,S,C,PS,FOFR,XTRA,NRMODE,PRMODE
C
C-----------------------------------------------------------------------------
C
C     PREVIOUS SLAB VARIABLES
C
      DO 600 J = 1, NRMODE
```

```
      PS(J) = S(   J)
      PHYTH(J) = HYTH(J)                                                00002310
      PHYTHP(J) = HYTHPR(J)                                             00002320
      PEYTH(J) = EYTH(J)                                                00002330
      PEYTHP(J) = EYTHPR(J)                                             00002340
      PHYOPR(J) = HYOPR(J)                                              00002350
      PEYO(J) = EYO(J)                                                  00002360
      PEYOPR(J) = EYOPR(J)                                              00002370
  600 CONTINUE                                                          00002380
      PRMODE=NRMODE
      NTHSQP=NTHSQ
C
C-----------------------------------------------------------------------
      IF(INTFLG .LT. 1) GO TO 42
      PRINT 900,M
      DO 450 K=1,PRMODE
      DO 450 J=1,NRMODE
      CALL MAGANG(INORM(J,K),AMAGG,ANGG)
      PRINT 901,J,K,INORM(J,K),AMAGG,ANGG
  450 CONTINUE
   42 CONTINUE
C
C-----------------------------------------------------------------------
      RETURN                                                            00002400
  900 FORMAT(1H0,14X,
     $ ' INORM = NORMALIZED CONVERSION COEFFICIENTS',
     $                                 6X,'SLAB NUMBER = ',I2,/)       00001410
901   FORMAT(' J =',I2,2X,' K =',I2,2X,' INORM = ',(1PE15.5,1PE15.5),
     $2X, 1PE15.5,0PF9.2,/)
906   FORMAT('0INTEGRALS IN SLAB',I3,/)                                 00002410
908   FORMAT(' NORM(',I2,',',I2,',',I2,') =',2E13.6,
     $10X,1PE15.5,0PF10.2)
910   FORMAT(' CAPI(',I2,',',I2,',',I2,') =',2E13.6,
     $10X,1PE15.5,0PF10.2)
      END
```

@PRT,S GRNDMCA.MCFLD

```
MORFITT*GRNDMCA(1).MCFLD
      SUBROUTINE MCFLD                                                  00002450
      IMPLICIT REAL *8(A-H,O-Z)                                         00002460
C   COMPUTE FIELDS FROM XVAL MIN TO XVAL MAX FOR TWO XMTR-RCVR DISTANCES00002470
C                                                                       00002480
      COMMON/FIRST C/ IFIRST
      COMMON/SNTR C/SNTR
      COMMON/INORM C/INORM
      COMMON /PREV C/ PS                                                00002490
      COMMON/TERM/NT,NTR
      COMMON/SPLOT/SAVED(402),Y1(402),Y2(402),ANG1(402),ANG2(402)
      COMMON/MCINPT/                FOFR(20  ),XVAL(50),FREQ,
     $   XTRA(20  ),TOPHT(50),RHOMAX,RHOMIN,DELRHO,DELTAX,
     $   EPSR,SIGMA,NRSLAB,NRMODE,NTMAX,PRMODE,NTRMDS
      COMMON/MCSTOR/A(20,20 ),S(20  ),C(20  ),KVRAOT,KVRATT,AVRKOT,     00004550
     &   AVRKTT,NTHSQ,CONST,OMEGA,WAVENO                                00002550
      COMMON/MCPLOT/R(402),DB(402),ANG(402),IDPLOT(10),ISUB,JPLOT,
     $  NAPLOT,NPPLOT
      COMPLEX*16 PS(20),PREVA(20,20),EXCNTR(20),SNTR(20)
      COMPLEX*16 THETA,A,S,C,XTRA,SOLNA(20),TB,TDBL,                    00002600
     $ IM/(0.0D0,1.0D0)/,TA,FOFR
      COMPLEX*16 INORM(20,20)
      REAL*8 NTHSQ
      INTEGER PRMODE                                                    00002610
      REAL*4 R,DB,ANG                                                   00002620
      REAL*4 SAVED,Y1,Y2
      REAL*4 ANG1,ANG2                                                  00002630
      REAL*8 KVRAOT,KVRATT
      DATA DTR/0.01745329252D0/                                         00002640
      DATA ERAD/6.37003/                                                00002650
C                                                                       00002660
C                                                                       00002670
      ISUB = 0                                                          00002680
      M = NTR                                                           00002690
      RHO = RHO MIN                                                     00002700
      X = RHO - 1.0                                                     00002710
  700 IF (RHO.LE.X)  GO TO 720
C
C        READ IN A NEW SLAB
C
   10 CONTINUE
C
      READ (4) NSLAB,INORM,S,C,PS,FOFR,XTRA,NRMODE,PRMODE
C
      IF(NSLAB .LT. NTR) GO TO 10
      IF(NSLAB .NE. NTR) GO TO 11
C
      NTRMDS=NRMODE
C
      DO 12 K=1,NTRMDS
```

```
      EXCNTR(K)=XTRA(K)
      SNTR(K) = S(K)
C
   12 CONTINUE
   11 CONTINUE
C
      CALL MCSTEP(M)
C
      DO 710  J = 1,NRMODE
      SOLN A(J) = (0.0D0,0.0D0)
      DO 710  K = 1,NTRMDS
      IF(M .NE. NTR) GO TO 35
      SOLN A(J) = SOLN A(J)+A(   J,K)*(EXCNTR(K)/SNTR(K))                   MORFITT
      GO TO 710                                                             00002770
   35 SOLN A(J) = SOLN A(J) + A(   J,K)*(EXCNTR(K)/SNTR(K)) *               MORFITT
     $    CDEXP(-IM*WAVENO*SNTR(K)*XVAL(NTR+1))
  710 CONTINUE                                                              00002800
C
      M = M + 1
      X = 1.0E6                                                             00002820
      IF(M .LE. NRSLAB) X = XVAL(M)
      GO TO 700                                                             00002840
C                                                                           00002850
  720 TA = (0.0D0,0.0D0)
      DO 730  J = 1,NRMODE
      IF(M-1 .NE. NTR) GO TO 45
      TB =CDEXP(-IM*WAVENO*S(J)*RHO)
      TA = TA+SOLNA(J)*S(J)*TB                                              MORFITT
      GO TO 730                                                             00002910
C
   45 TB =CDEXP(IM*WAVENO*     S(J)*(XVAL(M-1)-RHO))
      TA = TA+SOLNA(J)*S(J)*TB                                              MORFITT
C
  730 CONTINUE                                                              00002940
      TA = TA*CONST/DSQRT(DSIN(RHO/ERAD))                                   00002950
      TDBL = TA *CDEXP (IM * WAVE NO * RHO)                                 00002960
      CALL MAGANG (TDBL, TDMAG, TDANG)                                      00002970
      TSMAG = TDMAG                                                         00002980
      TSANG = TDANG                                                         00002990
      TSDB = 8.685890 * DLOG (TSMAG * 1.0E6)                                00003000
      ISUB = ISUB+1                                                         00003010
      R(ISUB) = RHO                                                         00003020
      DB(ISUB) = TSDB                                                       00003030
      ANG(ISUB) = TSANG                                                     00003040
      SAVED(NT) = XVAL(2)
      IF(MOD(ISUB,2) .EQ. 1) Y1(NT)=DB(ISUB)                                00003060
      IF(MOD(ISUB,2) .EQ. 0) Y2(NT)=DB(ISUB)                                00003070
      IF(MOD(ISUB,2) .EQ. 1) ANG1(NT) = ANG(ISUB)                           00003080
      IF(MOD(ISUB,2) .EQ. 0) ANG2(NT) = ANG(ISUB)                           00003090
      RHO = RHO + DEL RHO                                                   00003100
```

```
      IF (RHO.LE.RHO MAX)  GO 1O 700                                    00003110
      REWIND  4
      IF(NT .EQ. NTMAX) PRINT 910                                       00003120
      IF(NT .EQ. NTMAX) PRINT 920                                       00003130
      IF(NT .EQ. NTMAX) PRINT 925                                       00003140
      IF(NT .EQ. NTMAX) PRINT 930,(SAVED(JJ),Y1(JJ),ANG1(JJ),Y2(JJ),    00003150
     $  ANG2(JJ),JJ=1,NTMAX)                                            00003160
      IF(JPLOT .EQ. 0) RETURN
      IF(NT .EQ. NTMAX .AND. JPLOT .EQ. 1) GO TO 500
      RETURN                                                            00003190
C
  500 CONTINUE
      IF(IFIRST .EQ. 1) CALL PLOT(1.0,1.0,-3)
      IF(NAPLOT .EQ. 1) ITYPE=1
      IF(NAPLOT .EQ. 1) CALL MCPLTS(ITYPE)
      IF(NPPLOT .EQ. 1) ITYPE=2
      IF(NPPLOT .EQ. 1) CALL MCPLTS(ITYPE)
      RETURN
C
910   FORMAT('1',                                                       00003200
     $ ' ELECTRIC FIELD STRENGTH AS A FUNCTION OF TRANSMITTER-TERMINATOR00003210
     $ DISTANCE(D)',//)                                                 00003220
920   FORMAT(' ',26X,'FIELD AT RHOMIN   FIELD AT RHOMAX')               00003230
925   FORMAT(' ',19X,'D',6X,2('EZ(DB)  EZ(ANG)',3X),/)                  00003240
930   FORMAT(' ',15X,F9.2,4F9.4)                                        00003250
      END                                                               00003260
```


@PRT,S GRNDMCA.MCFLD2

```
MORFITT*GRNDMCA(1).MCFLD2
             SUBROUTINE MCFLD2                                                00003270
             IMPLICIT REAL *8(A-H,O-Z)                                        00002460
      C   COMPUTE FIELDS FROM XVAL MIN TO XVAL MAX FOR TWO XMTR-RCVR DISTANCES00002470
      C                                                                       00002480
             COMMON/FIRST C/ IFIRST
             COMMON/SNTR C/SNTR
             COMMON/INORM C/INORM
             COMMON /PREV C/ PS
             COMMON/TERM/NT,NTR                                               00002490
             COMMON/SPLOT/SAVED(402),Y1(402),Y2(402),ANG1(402),ANG2(402)
             COMMON/MCINPT/              FOFR(20  ),XVAL(50),FREQ,
           $   XTRA(20  ),TOPHT(50),RHOMAX,RHOMIN,DELRHO,DELTAX,
           $   EPSR,SIGMA,NRSLAB,NRMODE,NTMAX,PRMODE,NTRMDS
             COMMON/MCSTOR/A(20,20 ),S(20  ),C(20  ),KVRAOT,KVRATT,AVRKOT,    00004550
           &   AVRKTT,NTHSQ,CONST,OMEGA,WAVENO                                00002550
             COMMON/MCPLOT/R(402),DB(402),ANG(402),IDPLOT(10),ISUB,JPLOT,
           $  NAPLOT,NPPLOT
             COMPLEX*16 PS(20),PREVA(20,20),EXCNTR(20),SNTR(20)
             COMPLEX*16 THETA,A,S,C,XTRA,SOLNA(20),TB,TDBL,
           $ IM/(0.0D0,1.0D0)/,TA,FOFR                                        00002600
             COMPLEX*16 INORM(20,20)
             REAL*8 NTHSQ
             INTEGER PRMODE
             REAL*4 R,DB,ANG                                                  00002610
             REAL*4 SAVED,Y1,Y2                                               00002620
             REAL*4 ANG1,ANG2
             REAL*8 KVRAOT,KVRATT                                             00002630
             DATA DTR/0.0174532925200/
             DATA ERAD/6.370D3/                                               00002640
      C                                                                       00002650
             PRINT 910                                                        00003490
             PRINT 920, NRSLAB,(XVAL(JKL),JKL=1,NRSLAB)                       00003500
      C                                                                       00002660
             PRINT 628
         628 FORMAT('0',22X,'EZ' )
             PRINT 629
         629 FORMAT(2X,1(9X,'RHO(KM)',3X,'AMP(DB)',3X,'ANG(DEG)')/)           00039500
      C
             ISUB = 0                                                         00002670
             M = NTR                                                          00002680
             RHO = RHO MIN                                                    00002690
             X = RHO - 1.0                                                    00002700
         700 IF (RHO.LE.X)  GO TO 720                                         00002710
      C
      C         READ IN A NEW SLAB
      C
          10 CONTINUE
      C
             READ (4) NSLAB,INORM,S,C,PS,FOFR,XTRA,NRMODE,PRMODE
```

```
C
      IF(NSLAB .LT. NTR) GO TO 10
      IF(NSLAB .NE. NTR) GO TO 11
C
      NTRMDS=NRMODE
C
      DO 12 K=1,NTRMDS
      EXCNTR(K)=XTRA(K)
      SNTR(K) = S(K)
C
   12 CONTINUE
   11 CONTINUE
C
      CALL MCSTEP(M)
C
      DO 710  J = 1,NRMODE
      SOLN A(J) = (0.0D0,0.0D0)
      DO 710  K = 1,NTRMDS
      IF(M .NE. NTR) GO TO 35
      SOLN A(J) = SOLN A(J)+A(  J,K)*(EXCNTR(K)/SNTR(K))                MORFITT
      GO TO 710                                                         00002770
C
   35 SOLN A(J) = SOLN A(J) + A(  J,K)*(EXCNTR(K)/SNTR(K)) *             MORFITT
     $   CDEXP(-IM*WAVENO*SNTR(K)*XVAL(NTR+1))
  710 CONTINUE                                                          00002800
C
      M = M + 1
      X = 1.0E6                                                         00002820
      IF(M .LE. NRSLAB) X = XVAL(M)
      GO TO 700                                                         00002840
C                                                                       00002850
  720 TA = (0.0D0,0.0D0)
      DO 730  J = 1,NRMODE
      IF(M-1 .NE. NTR) GO TO 45
      TB =CDEXP(-IM*WAVENO*S(J)*RHO)
      TA = TA+SOLN A(J)*S(J)*TB                                         MORFITT
      GO TO 730                                                         00002910
C
   45 TB =CDEXP(IM*WAVENO*    S(J)*(XVAL(M-1)-RHO))
      TA = TA+SOLNA(J)*S(J)*TB                                          MORFITT
  730 CONTINUE                                                          00002940
      TA = TA*CONST/DSQRT(DSIN(RHO/ERAD))                               00002950
      TDBL = TA *CDEXP (IM * WAVE NO * RHO)                             00002960
      CALL MAGANG (TDBL, TDMAG, TDANG)                                  00002970
      TSMAG = TDMAG                                                     00002980
      TSANG = TDANG                                                     00002990
      TSDB = 8.685890 * DLOG (TSMAG * 1.0E6)                            00003000
C
      ISUB = ISUB+1                                                     00003010
      R(ISUB) = RHO                                                     00003020
```

```
      DB(ISUB) = TSDB                                              00003030
      ANG(ISUB) = TSANG                                            00003040
      PRINT 608,RHO,TSDB,TSANG
  608 FORMAT(2X,1(7X,F10.2,F10.5,F10.4))
      RHO = RHO + DEL RHO                                          00003100
      IF (RHO.LE.RHO MAX)  GO TO 700                               00003110
      REWIND  4
      IF(JPLOT .EQ. 1) GO TO 500
      RETURN                                                       00003190
C
  500 CONTINUE
      IF(IFIRST .EQ. 1) CALL PLOT(1.0,1.0,-3)
      IF(NAPLOT .EQ. 1) ITYPE=1
      IF(NAPLOT .EQ. 1) CALL MCPLT2(ITYPE)
      IF(NPPLOT .EQ. 1) ITYPE=2
      IF(NPPLOT .EQ. 1) CALL MCPLT2(ITYPE)
      RETURN
C
 910  FORMAT('1',                                                  00003970
     $ ' ELECTRIC FIELD STRENGTH AS A FUNCTION OF RHO',//)         00003980
 920  FORMAT(' X COORDINATES OF SLABS 1 THROUGH',I2,9F10.4,/,      00003990
     $11F10.4,////)                                                00004000
      END                                                          00004010
```

@PRT,S GRNDMCA.MCPLTS

```
MORFITT*GRNDMCA(1).MCPLTS
      SUBROUTINE MCPLTS(ITYPE)
      COMMON/PLOT C/FRQP,RHOMNP,RHOMXP
      COMMON/TERM/NT,NTR                                                00004030
      COMMON/SPLOT/SAVED(402),Y1(402),Y2(402),ANG1(402),ANG2(402)
      COMMON/MCPLOT/R(402),DB(402),ANG(402),IDPLOT(10),ISUB,JPLOT,
     $   NAPLOT,NPPLOT
      COMMON/XPLOT/XMIN,XINC,YMIN,YINC,SIZEX,SIZEY                      00004060
      COMMON/PSPLOT/PHSMIN,PHSINC,SIZEP,PTIC,NTICP
      COMMON/AXISM C/XTIC,YTIC,NTICX,NTICY
      REAL*8 FRQP,RHOMNP,RHOMXP
      REAL*4 SIZEP,PHSMIN,PHSINC,PTIC
      REAL*4 XTIC,YTIC
      SAVED(NT+1) = XMIN                                                00004070
      SAVED(NT+2) = XINC                                                00004080
      Y1(NT+1) = YMIN                                                   00004090
      Y1(NT+2) = YINC                                                   00004100
      Y2(NT+1) = YMIN                                                   00004110
      Y2(NT+2) = YINC                                                   00004120
      ANG1(NT+1) = PHSMIN
      ANG1(NT+2) = PHSINC
      ANG2(NT+1) = PHSMIN
      ANG2(NT+2) = PHSINC
      IF(ITYPE .EQ. 2) GO TO 800
C
C        ITYPE=1
      DO 900 I=1,2
      CALL AXISM(0.,0.,'TRANSMITTER-TERMINATOR DISTANCE IN KM',-37,
     $ SIZEX,0.0,SAVED(NT+1),SAVED(NT+2),XTIC,NTICX)
      IF(I .EQ. 1)
     $CALL AXISM(0.,0.,'DB ABOVE 1UV/M FOR 1KW',22,SIZEY,90.0,
     $ Y1(NT+1),Y1(NT+2),YTIC,NTICY)
      IF(I .EQ. 2)
     $CALL AXISM(0.,0.,'DB ABOVE 1UV/M FOR 1KW',22,SIZEY,90.0,
     $ Y2(NT+1),Y2(NT+2),YTIC,NTICY)
      IF(I .EQ. 1) CALL LINE(SAVED,Y1,NT,1,0,11)
      IF(I .EQ. 2) CALL LINE(SAVED,Y2,NT,1,0,11)
      CALL SYMBOL(1.0,(SIZEY+0.6),0.14,IDPLOT,0.0,40)
      CALL SYMBOL(1.0,(SIZEY+0.4),0.14,'FREQ=',0.0,5)
      CALL NUMBER(1.9,(SIZEY+0.4),0.14,SNGL(FRQP),0.0,3)
      CALL SYMBOL(1.0,(SIZEY+0.2),0.14,'RECEIVER DISTANCE = ',0.0,20)
      IF(I .EQ. 1) CALL NUMBER(3.9,(SIZEY+0.2),0.14,SNGL(RHOMNP),0.0,1)
      IF(I .EQ. 2) CALL NUMBER(3.9,(SIZEY+0.2),0.14,SNGL(RHOMXP),0.0,1)
      CALL PLOT(SIZEX+5.,0.,-3)                                         00004290
  900 CONTINUE
      RETURN                                                            00004300
  800 CONTINUE
C
C        ITYPE=2
      DO 700 I=1,2
```

```
          CALL AXISM(0.,0.,'TRANSMITTER-TERMINATOR DISTANCE IN KM',-37,
         $ SIZEX,0.0,SAVED(NT+1),SAVED(NT+2),XTIC,NTICX)
          IF(I .EQ. 1)
         *CALL AXISM(0.0,0.0,'PHASE(DEGREES)',14,SIZEP,90.0,
         * ANG1(NT+1),ANG1(NT+2),PTIC,NTICP)
          IF(I .EQ. 2)
         *CALL AXISM(0.0,0.0,'PHASE(DEGREES)',14,SIZEP,90.0,
         * ANG2(NT+1),ANG2(NT+2),PTIC,NTICP)
          IF(I .EQ. 1) CALL LINE(SAVED,ANG1,NT,1,0,11)
          IF(I .EQ. 2) CALL LINE(SAVED,ANG2,NT,1,0,11)
          CALL SYMBOL(1.0,(SIZEP+0.6),0.14,IDPLOT,0.0,40)
          CALL SYMBOL(1.0,(SIZEP+0.4),0.14,'FREQ=',0.0,5)
          CALL NUMBER(1.9,(SIZEP+0.4),0.14,SNGL(FRQP),0.0,3)
          CALL SYMBOL(1.0,(SIZEP+0.2),0.14,'RECEIVER DISTANCE = ',0.0,20)
          IF(I .EQ. 1) CALL NUMBER(3.9,(SIZEP+0.2),0.14,SNGL(RHOMNP),0.0,1)
          IF(I .EQ. 2) CALL NUMBER(3.9,(SIZEP+0.2),0.14,SNGL(RHOMXP),0.0,1)
          CALL PLOT(SIZEX+5.,0.,-3)
      700 CONTINUE
          RETURN
          END                                                               00004310

@PRT,S GRNDMCA.MCPLT2
```

MORFITT*GRNDMCA(1).MCPLT2

```
      SUBROUTINE MCPLT2(ITYPE)
      COMMON/PLOT C/FRQP,RHOMNP,RHOMXP
      COMMON/PSPLOT/PHSMIN,PHSINC,SIZEP,PTIC,NTICP
      COMMON/AXISM C/XTIC,YTIC,NTICX,NTICY
      COMMON/MCPLOT/R(402),DB(402),ANG(402),IDPLOT(10),ISUB,JPLOT,
     $  NAPLOT,NPPLOT
      COMMON/XPLOT/XMIN,XINC,YMIN,YINC,SIZEX,SIZEY                      00004340
      REAL*8 FRQP,RHOMNP,RHOMXP
      REAL*4 XTIC,YTIC
      REAL*4 SIZEP,PHSMIN,PHSINC,PTIC
      R(ISUB+1) = XMIN                                                  00004350
      R(ISUB+2) = XINC                                                  00004360
      DB(ISUB+1) = YMIN                                                 00004370
      DB(ISUB+2) = YINC                                                 00004380
      ANG(ISUB+1) = PHSMIN
      ANG(ISUB+2) = PHSINC
      IF(ITYPE .EQ. 2) GO TO 800
C
C     ITYPE = 1
      CALL AXISM(0.0,0.0,7HRHO(KM),-7,SIZEX,0.,R(ISUB+1),R(ISUB+2),
     $ XTIC,NTICX)
      CALL AXISM(0.0,0.0,22HDB ABOVE 1UV/M FOR 1KW,22,SIZEY,90.,
     $ DB(ISUB+1),DB(ISUB+2),YTIC,NTICY)
      CALL LINE(R,DB,ISUB,1,0,4)
      CALL SYMBOL(1.0,(SIZEY+0.6),0.14,IDPLOT,0.0,40)
      CALL SYMBOL(1.0,(SIZEY+0.4),0.14,'FREQ=',0.0,5)
      CALL NUMBER(1.9,(SIZEY+0.4),0.14,SNGL(FRQP),0.0,3)
      CALL PLOT(SIZEX+5.,0.,-3)                                         00004450
      RETURN                                                            00004460
  800 CONTINUE
C
C     ITYPE = 2
      CALL AXISM(0.0,0.0,7HRHO(KM),-7,SIZEX,0.,R(ISUB+1),R(ISUB+2),
     $ XTIC,NTICX)
      CALL AXISM(0.0,0.0,'PHASE(DEGREES)',14,SIZEP,90.0,
     * ANG(ISUB+1),ANG(ISUB+2),PTIC,NTICP)
      CALL LINE(R,ANG,ISUB,1,0,4)
      CALL SYMBOL(1.0,(SIZEP+0.6),0.14,IDPLOT,0.0,40)
      CALL SYMBOL(1.0,(SIZEP+0.4),0.14,'FREQ=',0.0,5)
      CALL NUMBER(1.9,(SIZEP+0.4),0.14,SNGL(FRQP),0.0,3)
      CALL PLOT(SIZEX+5.,0.,-3)
      RETURN
      END                                                               00004470
```

@PRT,S GRNDMCA.MCSTEP

```
MORFITT*GRNDMCA(1).MCSTEP
      SUBROUTINE MCSTEP(M)                                              00004480
      IMPLICIT REAL *8(A-H,O-Z)                                         00004490
      COMMON/SNTR C/SNTR
      COMMON/INT C/INTFLG,IPRNTA
      COMMON/NPRNT C/NPRINT
      COMMON /PREV C/ PS
      COMMON/INORM C/INORM
      COMMON/TERM/NT,NTR                                                00004500
      COMMON/MCINPT/                  FOFR(20   ),XVAL(50),FREQ,
     $   XTRA(20   ),TOPHT(50),RHOMAX,RHOMIN,DELRHO,DELTAX,
     $   EPSR,SIGMA,NRSLAB,NRMODE,NTMAX,PRMODE,NTRMDS
      COMMON/MCSTOR/A(20,20 ),S(20   ),C(20   ),KVRAOT,KVRATT,AVRKOT,  00004550
     &   AVRKTT,NTHSQ,CONST,OMEGA,WAVENO                                00004560
      COMPLEX*16 PS(20),PREVA(20,20),SNTR(20)
      COMPLEX*16 INORM(20,20)
      COMPLEX*16 THETA,FOFR,A,S,C,
     $  IM/(0.0D0,1.0D0)/,B(20),XTRA
      REAL*8 NTHSQ
      INTEGER PRMODE
      REAL*8 KVRAOT,KVRATT                                              00004600
C                                                                       00004620
      MP=M-1
      IF(M .NE. NTR) GO TO 50
      DO 32 K=1,NTRMDS
      DO 32 J=1,NRMODE
      IF(J .EQ. K) GO TO 31
      A(J,K) = (0.0D0,0.0D0)
      GO TO 32
   31 A(J,K) = (1.0D0,0.0D0)
   32 CONTINUE
      GO TO 24
C
C-----------------------------------------------------------------------
C
C     FOR SLAB(M) NOT EQUAL TO SLAB(NTR)
C
   50 CONTINUE
      DO 17 N = 1,NRMODE                                                00004650
17    B(N) = (0.,0.)                                                    00004660
      IF(MP .EQ. NTR) GO TO 21                                          00004670
C
C-----------------------------------------------------------------------
C
C     FOR SLAB(MP) NOT EQUAL TO SLAB(NTR)
C
      DO 29 K = 1,NTRMDS
      DO 33 L = 1,NRMODE                                                00004690
      DO 33 J = 1,PRMODE
   33 B(L) = B(L)+INORM(L,J  )*CDEXP(-IM*WAVENO*  PS(J)*(XVAL(M)-
```

```
      $   XVAL(MP) ))*PREVA(J,K)
      DO 27 I = 1,NRMODE                                            00004750
   27 A(   I,K) =    B(I)                                            MORFITT
C  27 A(   I,K) =    B(I)*S(I)/SNTR(K)                               PAPPERT
      DO 18 N=1,NRMODE                                              00004770
18    B(N) = (0.,0.)                                                00004780
   29 CONTINUE                                                      00004790
      GO TO 24                                                      00004800
C
C-----------------------------------------------------------------------
C
C     FOR SLAB(MP) EQUAL TO SLAB(NTR)
C
   21 DO 23 K = 1,NTRMDS
      DO 25 L = 1,NRMODE                                            00004830
   25 B(L) = INORM(L,K   )
      DO 35 J = 1,NRMODE                                            00004870
   35 A(   J,K) =    B(J)                                            MORFITT
C  35 A(   J,K) =    B(J)  *S(J)/SNTR(K)                             PAPPERT
   23 CONTINUE                                                      00004890
   24 CONTINUE                                                      00004900
C
C-----------------------------------------------------------------------
C
      DO 40 K=1,NTRMDS
      DO 40 J=1,NRMODE
   40 PREVA(J,K)=A(J,K)
C
C-----------------------------------------------------------------------
C
      IF(IPRNTA .LT. 1) GO TO 42
      PRINT 900,M
      DO 450 K = 1,NTRMDS
      DO 450 J = 1,NRMODE
      CALL MAGANG(A(J,K),AMAGG,ANGG)
      PRINT 901,J,K,A(   J,K),AMAGG,ANGG
  450 CONTINUE
  900 FORMAT(1H ,14X,
     $ 'A = TOTAL CONVERSION COEFFICIENTS',6X,'SLAB NUMBER = ',I2,/)     00001410
901   FORMAT(' J =',I2,2X,' K =',I2,2X,' A = ',(1PE15.5,1PE15.5),
     $2X, 1PE15.5,0PF9.2,/)
   42 CONTINUE
C
      RETURN                                                        00004910
      END                                                           00004920

@PRT,S GRNDMCA.MDHNKL
```

```
MORFITT*GRNDMCA(1).MDHNKL
      SUBROUTINE MDHNKL (Z,H1,H2,H1PRME,H2PRME)                         00004930
      IMPLICIT REAL *8 (A-H,O-Z)                                        00004940
      COMPLEX*16 Z,I,H1,H2,H1PRME,H2PRME,ZPOWER,TERM1,TERM2,            00004950
     $           TERM3,ZTERM,TERM,SUM1,SUM2,SUM3,SUM4,SQRTZB,           00004960
     $           EXP1,EXP2,EXP3,EXP4,EXP5,GM2F,GPMFP,MPOWER,BETA,RTZ,   00004970
     $           CONST1,CONST2,CONST3,CONST4                            00004980
      DIMENSION A(23), B(23), C(23), D(23), CAP(14)                     00004990
      DATA A/                                                           00005000
     $   9.30436716930000D-01,3.10145572309700D 01,2.06763714873160D 02,00005010
     $   5.74343652425450D 02,8.70217655190080D 02,8.28778719228640D 02,00005020
     $   5.41685437404340D 02,2.57945446383020D 02,9.34584950663100D 01,00005030
     $   2.66263518707400D 01,6.12100043005600D 00,1.15928038448000D 00,00005040
     $   1.84012759441000D-01,2.48330309640000D-02,2.88420801000000D-03,00005050
     $   2.91334142000000D-04,2.58274950000000D-05,2.02568600000000D-06,00005060
     $   1.41557000000000D-07,8.87000000000000D-09,5.01000000000000D-10,00005070
     $   2.60000000000000D-11,1.00000000000000D-12/                     00005080
      DATA B/                                                           00005090
     $   6.78298725140000D-01,1.13049787524000D 01,5.38332321543100D 01,00005100
     $   1.19629404787350D 02,1.53371031778650D 02,1.27809193148880D 02,00005110
     $   7.47422182157200D 01,3.23559386215200D 01,1.07853128738400D 01,00005120
     $   2.85325737403000D 00,6.13603736351000D-01,1.09376780098000D-01,00005130
     $   1.64229399550000D-02,2.10550512200000D-03,2.33167788000000D-04,00005140
     $   2.25282890000000D-05,1.91567100000000D-06,1.44470000000000D-07,00005150
     $   9.72900000000000D-09,5.89000000000000D-10,3.20000000000000D-11,00005160
     $   2.00000000000000D-12,0.00000000000000D 00/                     00005170
      DATA C/                                                           00005180
     $   4.65218358460000D-01,6.20291144619000D 00,2.58454643591500D 01,00005190
     $   5.22130593114000D 01,6.21584039421500D 01,4.87516893663900D 01,00005200
     $   2.70842718702200D 01,1.12150194079600D 01,3.59455750255000D 00,00005210
     $   9.18150064510000D-01,1.91281263439000D-01,3.31222966990000D-02,00005220
     $   4.84244103800000D-03,6.05683682000000D-04,6.55501820000000D-05,00005230
     $   6.19859900000000D-06,5.16550000000000D-07,3.82200000000000D-08,00005240
     $   2.52800000000000D-09,1.50000000000000D-10,8.00000000000000D-12,00005250
     $   0.00000000000000D 00,0.00000000000000D 00/                     00005260
      DATA D/                                                           00005270
     $   6.78298725140000D-01,4.52199150096200D 01,3.76832625080150D 02,00005280
     $   1.19629404787350D 03,1.99382341312250D 03,2.04494709038206D 03,00005290
     $   1.42010214609865D 03,7.11830649673510D 02,2.69632821846030D 02,00005300
     $   7.98912064729000D 01,1.90217158268800D 01,3.71881052333900D 00,00005310
     $   6.07648778323000D-01,8.42202048960000D-02,1.00262148690000D-02,00005320
     $   1.03630127800000D-03,9.38678690000000D-05,7.51243500000000D-06,00005330
     $   5.35074000000000D-07,3.41350000000000D-08,1.96200000000000D-09,00005340
     $   1.02000000000000D-10,5.00000000000000D-12/                     00005350
      DATA CAP/                                                         00005360
     $   1.04166666666667D-01,8.35503472222222D-02,1.28226574556327D-01,00005370
     $   2.91849026464140D-01,8.81627267443758D-01,3.32140828186277D 00,00005380
     $   1.49957629868626D 01,7.89230130115870D 01,4.74451538868000D 02,00005390
     $   3.20749009100000D 03,2.40865496000000D 04,1.98923120000000D 05,00005400
     $   1.79190200000000D 06,1.74843770000000D 07/                     00005410
```

```
C
      DATA I/(0.0D0,1.0D0)/
      DATA ROOT3/1.73205080756888D 00/
      DATA ALPHA/8.53667218838951D-01/
      DATA CONST1/( 2.58819045102522D-01,-9.65925826289067D-01)/
      DATA CONST2/( 2.58819045102522D-01, 9.65925826289067D-01)/
      DATA CONST3/(-9.65925826289067D-01, 2.58819045102522D-01)/
      DATA CONST4/(-9.65925826289067D-01,-2.58819045102522D-01)/
C
      ZPOWER=1.0
      SUM3=0.0
      SUM4=0.0
      ZMAG=CDABS(Z)
      IF(ZMAG .GT. 4.2) GO TO 70
      IF(ZMAG .GE. 3.2) GO TO 10
      N=12
      GO TO 30
   10 IF(ZMAG .GE. 4.1) GO TO 20
      N=15
      GO TO 30
   20 N=23
   30 SUM1=0.
      SUM2=0.
      ZTERM=-Z**3/200.0
      DO 50 M=1,N
      SUM1=SUM1+A(M)*ZPOWER
      SUM2=SUM2+B(M)*ZPOWER
      SUM3=SUM3+C(M)*ZPOWER
      SUM4=SUM4+D(M)*ZPOWER
      ZPOWER=ZPOWER*ZTERM
      IF(CDABS(ZPOWER) .LE. 1.0D-30) GO TO 60
   50 CONTINUE
   60 GM2F=I*(Z*SUM2-2.*SUM1)/ROOT3
      GPMFP=I*(SUM4+2.*Z*Z*SUM3)/ROOT3
      H1=Z*SUM2+GM2F
      H2=H1-2.0*GM2F
      H1PRME=SUM4+GPMFP
      H2PRME=H1PRME-2.0*GPMFP
      RETURN
C
   70 SUM1=1.0
      SUM2=1.0
      RTZ=CDSQRT(Z)
      SQRT [illegible] Z
      ZTERM= [illegible] TZB
      MPOWER=1.0
      TERM=-1.5/Z
      DO 80 M=1,14
      ZPOWER=ZPOWER*ZTERM
      MPOWER=MPOWER*(-ZTERM)
```

```
      TERM1=CAP(M)*ZPOWER
      TERM2=CAP(M)*MPOWER
      SUM1=SUM1+TERM1
      SUM2=SUM2+TERM2
      SUM3=SUM3+M*TERM1
      SUM4=SUM4+M*TERM2
   80 CONTINUE
      SUM3=SUM3*TERM
      SUM4=SUM4*TERM
      EXP1=CDEXP(2.*I*SQRTZB/3.)
      EXP2=EXP1*CONST1
      EXP3=CONST2/EXP1
      EXP4=CONST3*EXP1
      EXP5=CONST4/EXP1
      BETA=ALPHA/CDSQRT(RTZ)
      ZREAL=Z
      ZIMAG=-I*Z
      IF (ZREAL.GE.0.0.OR.ZIMAG.GE.0.0)GO TO 90
      H1=BETA*(EXP2*SUM2+EXP5*SUM1)
      H1PRME=BETA*(EXP2*(SUM2*(-0.25/Z+I*RTZ)+SUM4)+EXP5*(SUM1*(-0.25/Z
     $       -I*RTZ)+SUM3))
      GO TO 110
   90 H1=BETA*EXP2*SUM2
      H1PRME=BETA*EXP2*(SUM2*(-0.25/Z+I*RTZ)+SUM4)
  110 IF (ZREAL.GE.0.0.OR.ZIMAG.LT.0.0)GO TO 120
      H2=BETA*(EXP3*SUM1+EXP4*SUM2)
      H2PRME=BETA*(EXP3*(SUM1*(-0.25/Z-I*RTZ)+SUM3)+EXP4*(SUM2*(-0.25/Z
     $       +I*RTZ)+SUM4))
      RETURN
  120 H2=BETA*EXP3*SUM1
      H2PRME=BETA*EXP3*(SUM1*(-0.25/Z-I*RTZ)+SUM3)
      RETURN
      END
```

@PRT,S GRNDMCA.MAGANG

```
MORFITT*GRNDMCA(1).MAGANG
            SUBROUTINE MAGANG(ARG,AMAG,ANGLE)
            IMPLICIT REAL*8 (A-H,O-Z)
            COMPLEX*16 ARG
            DATA RDTDEG/5.729577951D1/
            ARGR=DREAL(ARG)
            ARGI=DIMAG(ARG)
            AMAG=CDABS(ARG)
            IF(ARGR .EQ. 0.0D0 .AND. ARGI .EQ. 0.0D0) GO TO 10
            ANGLE = DATAN2(ARGI,ARGR)*RDTDEG
            IF(ARGI .LT. 0.0D0) ANGLE=ANGLE+360.0D0
            RETURN
      C
         10 ANGLE=0.0D0
            RETURN
            END

@PRT,S GRNDMCA.AXISM
```

MORFITT*GRNDMCA(1).AXISM

```
      SUBROUTINE AXISM (X,Y,BCD,NC,SIZE,THETA,XMIN,DX,TIC,NTIC)         AXI   1
C                                                                       AXI   2
C     (X,Y)        COORDINATES OF THE BEGINNING OF THE AXIS             AXI   3
C     BCD          ALPHANUMERIC ANRAY CONTAINING THE AXIS LABEL         AXI   4
C     NC           NUMBER OF CHARACTERS IN AXIS LABEL.  IF NC .GT. 0,   AXI   5
C                  THE AXIS ANNOTATION WILL BE ON THE COUNTER-CLOCKWISE AXI   6
C                  SIDE OF THE AXIS.  NC .LT. 0 PLACES THE ANNOTATION ONAXI   7
C                  THE CLOCKWISE SIDE                                   AXI   8
C     SIZE         LENGTH OF THE AXIS IN INCHES                         AXI   9
C     THETA        THE ANGLE AT WHICH THE AXIS IS TO BE DRAWN           AXI  10
C     XMIN         THE VALUE OF THE COORDINATE AT THE BEGINNING OF THE  AXI  11
C                  AXIS.                                                AXI  12
C     DX           THE CHANGE IN COORDINATE VALUE BETWEEN SUCCESSIVE    AXI  13
C                  LABELED TIC-MARKS.                                   AXI  14
C     TIC          THE DISTANCE BETWEEN TIC-MARKS, IN INCHES            AXI  15
C     NTIC         THE REPEAT CYCLE FOR PLACING COORDINATE VALUES AT    AXI  16
C                  TIC MARKS -                                          AXI  17
C                  .EQ. 1 CAUSES VALUES TO BE PLACED AT EVERY TIC-MARK  AXI  18
C                  .EQ. 2 CAUSES VALUES TO BE PLACED AT EVERY SECOND    AXI  19
C                         TIC MARK, ETC.                                AXI  20
C                  .EQ. 0 SUPPRESSES ALL COORDINATE VALUES              AXI  21
C                                                                       AXI  22
C     J MARTIN     JUNE 1966                                            AXI  23
C                                                                       AXI  24
      DIMENSION BCD(2)                                                  AXI  25
      INTEGER ALPHA(2)                                                  AXI  26
         DATA ALPHA(1)/'(X10'/,ALPHA(2)/'  ) '/                         DMP
      SYGN=1.0                                                          AXI  27
      IF (NC) 5,10,10                                                   AXI  28
    5 SYGN=-1.0                                                         AXI  29
   10 NAC=IABS(NC)                                                      AXI  30
      SWITCH=0.0                                                        AXI  31
      TH=THETA*0.01745329                                               AXI  32
      CTH=COS(TH)                                                       AXI  33
      STH=SIN(TH)                                                       AXI  34
      DXT=TIC*CTH                                                       AXI  35
      DYT=TIC*STH                                                       AXI  36
      N=SIZE/TIC                                                        AXI  37
      TN=N                                                              AXI  38
      XB=X                                                              AXI  39
      YB=Y                                                              AXI  40
      XA=X-0.05*SYGN*STH                                                AXI  41
      YA=Y+0.05*SYGN*CTH                                                AXI  42
      CALL PLOT (XA,YA,3)                                               AXI  43
C         DRAW TICS.*                                                   AXI  44
      DO 15 I=1,N                                                       AXI  45
      CALL PLOT (XB,YB,2)                                               AXI  46
      XC=XB+DXT                                                         AXI  47
      YC=YB+DYT                                                         AXI  48
```

```
      CALL PLOT (XC,YC,2)                                               AXI  49
      XA=XA+DXT                                                         AXI  50
      YA=YA+DYT                                                         AXI  51
      CALL PLOT (XA,YA,2)                                               AXI  52
      XB=XC                                                             AXI  53
   15 YB=YC                                                             AXI  54
      IF (NTIC) 25,20,25                                                AXI  55
   20 EXPX=0.0                                                          AXI  56
      GO TO 90                                                          AXI  57
   25 ADX=ABS(DX)                                                       AXI  58
C          CALCULATE VALUE OF LAST LABELED TIC.=                        AXI  59
      ABSV=XMIN+DX*N/NTIC                                               AXI  60
      EXPX=0.0                                                          AXI  61
      IF (ADX) 30,90,30                                                 AXI  62
   30 IF (ADX-100.0) 45,35,35                                           AXI  63
   35 ADX=ADX/10.0                                                      AXI  64
      ABSV=ABSV/10.0                                                    AXI  65
      EXPX=EXPX+1.0                                                     AXI  66
      GO TO 30                                                          AXI  67
   40 ADX=ADX*10.0                                                      AXI  68
      ABSV=ABSV*10.0                                                    AXI  69
      EXPX=EXPX-1.0                                                     AXI  70
   45 IF (ADX-0.01) 40,90,90                                            AXI  71
   50 M=N                                                               AXI  72
      MM=N+1                                                            AXI  73
      DO 65 I=1,MM                                                      AXI  74
      K=MM-I                                                            AXI  75
      AK=FLOAT(K)/FLOAT(NTIC)-FLOAT(K/NTIC)                             AXI  76
      IF (AK) 55,60,55                                                  AXI  77
   55 XB=XB-DXT                                                         AXI  78
      YB=YB-DYT                                                         AXI  79
      ABSV=ABSV-(ADX/NTIC)
      GO TO 65                                                          AXI  80
   60 XA=XB-(0.20*SYGN-0.05)*STH-0.17143*CTH                            AXI  81
      YA=YB+(0.20*SYGN-0.05)*CTH-0.17143*STH                            AXI  82
      GO TO 70                                                          AXI  83
   65 CONTINUE                                                          AXI  84
   70 N=K/NTIC+1                                                        AXI  85
      DO 80 I=1,N                                                       AXI  86
C          LABEL TICS, IN REVERSE ORDER.=                               AXI  87
      CALL NUMBER (XA,YA,0.1,ABSV,THETA,2)                              AXI  88
      ABSV = ABSV - ADX
      XA=XA-DXT*FLOAT(NTIC)                                             AXI  90
      YA=YA-DYT*FLOAT(NTIC)                                             AXI  91
      IF (SWITCH) 80,75,80                                              AXI  92
   75 CALL WHERE (XW,YW,FACT)                                           AXI  93
      D1=SQRT((XW-XT)**2+(YW-YT)**2)                                    AXI  94
      D2=SQRT((XW-XA)**2+(YW-YA)**2)                                    AXI  95
      IF (D1-D2) 110,110,80                                             AXI  96
   80 CONTINUE                                                          AXI  97
```

```
85     RETURN                                                       AXI  98
90     IF (EXPX) 95,100,95                                          AXI  99
95     TNC=NAC+7                                                    AXI 100
C ***** THE NEXT TWO STATEMENTS HAVE BEEN REPLACED BY DATA          DMP
C ***** STATEMENTS BECAUSE THE CHARACTERS DESIRED DO NOT HAVE       DMP
C ***** THE SAME INTEGER EQUIVALENTS ON THE 1110                    DMP
C      ALPHA(1)=240+256*(241+256*(231+256*77))                      DMP
C      ALPHA(2)=64+256*(93+256*(64+256*64))                         DMP
       GO TO 105                                                    AXI 103
100    TNC=NAC                                                      AXI 104
105    XT=X+(SIZE/2.0-0.07*TNC)*CTH-(-0.07+SYGN*0.4225)*STH         AXI 105
       YT=Y+(SIZE/2.0-0.07*TNC)*STH+(-0.07+SYGN*0.4225)*CTH         AXI 106
       IF (NTIC) 50,110,50                                          AXI 107
C          DRAW AXIS NAME.=                                         AXI 108
110    CALL SYMBOL (XT,YT,0.14,BCD(1),THETA,NAC)                    AXI 109
       IF (EXPX) 120,115,120                                        AXI 110
115    SWITCH=1.0                                                   AXI 111
       IF (NTIC) 80,85,80                                           AXI 112
120    XT=XT+((TNC-6.0)*0.14)*CTH                                   AXI 113
       YT=YT+((TNC-6.0)*0.14)*STH                                   AXI 114
       CALL SYMBOL (XT,YT,0.14,ALPHA(1),THETA,7)                    AXI 115
       XT=XT+0.56*CTH-0.07*STH                                      AXI 116
       YT=YT+0.56*STH+0.07*CTH                                      AXI 117
       CALL NUMBER (XT,YT,0.10,EXPX,THETA,-1)                       AXI 118
       GO TO 115                                                    AXI 119
       END                                                          AXI 120-

@PRT,S GRNDMCA.CLINEQ
```

MORFITT*GRNDMCA(1).CLINEQ

```
      SUBROUTINE CLIN EQ (A, B, X, N,                                  00000100
     $   N DIM, IFLAG, ERR)                                             00000200
C                                                                       00000300
C   CLIN EQ USES L-U DECOMPOSITION TO                                   00000400
C   FIND THE TRIANGULAR MATRICES L, U                                   00000500
C   SUCH THAT  L * U = A.   L AND U ARE                                 00000600
C   STORED IN A.  THIS FORM IS USED WITH                                00000700
C   BACK-SUBSTITUTION TO FIND THE SOLN                                  00000800
C   X OF   A * X = L * U * X = B.                                       00000900
C   N IS THE NUMBER OF EQUATIONS AND                                    00001000
C   N DIM IS THE DIMENSION OF ALL ARRAYS                                00001100
C   IN THE PARAMETER LIST.                                              00001200
C                                                                       00001300
C   IF IFLAG = 0, L, U, AND X ARE                                       00001400
C   COMPUTED.                                                           00001500
C   IF IFLAG IS NON-ZERO, IT IS ASSUMED                                 00001600
C   THAT L AND U HAVE BEEN COMPUTED IN                                  00001700
C   A PREVIOUS CALL AND ARE STILL STORED                                00001800
C   IN A.  THUS ONLY X IS COMPUTED.                                     00001900
C   ERR  IS THE ESTIMATED RELATIVE                                      00002000
C   ERROR OF THE SOLUTION VECTOR.                                       00002100
C                                                                       00002200
      COMPLEX*16  A, B, X, T                                            00002300
      INTEGER*4  IROW
      DIMENSION  A(N DIM, N DIM),                                       00002500
     $  B(N DIM), X(N DIM)                                              00002600
      DIMENSION  IROW(50), Q(50)                                        00002700
      DATA  EPS /1.0E-15/                                               00002800
C                                                                       00002900
C                                                                       00003000
      IF (N.GT.50)  GO TO 900                                           00003100
      IF (IFLAG.NE.0)  GO TO 600                                        00003200
      DO 050  I = 1,N                                                   00003300
      Q(I) = 0.0                                                        00003400
      DO 040  J = 1,N                                                   00003500
      QQ = CDABS (A(I,J))                                               00003600
  040 IF (Q(I).LT.QQ)  Q(I) = QQ                                        00003700
      IF (Q(I).EQ.0.0)  GO TO 901                                       00003800
  050 CONTINUE                                                          00003900
      ERR = EPS                                                         00004000
      PPIV = 0.0                                                        00004100
      DO 100  I = 1,N                                                   00004200
  100 IROW(I) = I                                                       00004300
C                                                                       00004400
      DO 500  L = 1,N                                                   00004500
      PIVOT = 0.0                                                       00004600
      K = L - 1                                                         00004700
      DO 240  I = L,N                                                   00004800
      IF (K.LT.1)  GO TO 230                                            00004900
```

```
      DO 220  J = 1,K                                                   00005000
  220 A(I,L) = A(I,L) - A(J,L) * A(I,J)                                 00005100
  230 F = CDABS (A(I,L)) / Q(I)                                         00005200
      IF (PIVOT.GT.F)  GO TO 240                                        00005300
      PIVOT = F                                                         00005400
      NPIVOT = I                                                        00005500
  240 CONTINUE                                                          00005600
      IF (PIVOT.EQ.0.0)  GO TO 901                                      00005700
      IF (PPIV.LE.PIVOT)  GO TO 250                                     00005710
      ERR = ERR * PPIV / PIVOT                                          00005720
      IF (ERR.GE.1.0)  GO TO 901                                        00005730
  250 PPIV = PIVOT                                                      00005740
      IF (NPIVOT.EQ.L)  GO TO 280                                       00005750
      Q(NPIVOT) = Q(L)                                                  00005800
      J = IROW(L)                                                       00005900
      IROW(L) = IROW(NPIVOT)                                            00006000
      IROW(NPIVOT) = J                                                  00006100
      DO 260  I = 1,N                                                   00006700
      T = A(L,I)                                                        00006800
      A(L,I) = A(NPIVOT,I)                                              00006900
      A(NPIVOT,I) = T                                                   00007000
  260 CONTINUE                                                          00007100
  280 IF (L.EQ.N)  GO TO 500                                            00007110
      T = (1.0D0,0.0D0) / A(L,L)                                        00007200
      K = L + 1                                                         00007300
      M = L - 1                                                         00007400
      DO 450  I = K,N                                                   00007600
      IF (M.LT.1)  GO TO 400                                            00007700
      DO 350  J = 1,M                                                   00007800
  350 A(L,I) = A(L,I) - A(L,J) * A(J,I)                                 00007900
  400 A(L,I) = T * A(L,I)                                               00008000
  450 CONTINUE                                                          00008100
  500 CONTINUE                                                          00008200
      IF (ERR.GT.1.0E-5)   PRINT 998, ERR                               00008300
C                                                                       00008400
C                                                                       00008500
  600 DO 620  I = 2,N                                                   00008600
  620 X(I) = (0.0D0,0.0D0)                                              00008700
      J = IROW(1)                                                       00008800
      X(1) = B(J) / A(1,1)                                              00008900
      DO 700  I = 2,N                                                   00009000
      J = IROW(I)                                                       00009100
      K = I - 1                                                         00009200
      DO 650  L = 1,K                                                   00009300
  650 X(I) = X(I) + A(I,L) * X(L)                                       00009400
      X(I) = (B(J) - X(I)) / A(I,I)                                     00009500
  700 CONTINUE                                                          00009600
      K = N - 1                                                         00009700
      DO 800  I = 1,K                                                   00009800
      J = N - I                                                         00009900
```

```
      M = J + 1
      DO 800  L = M,N
      X(J) = X(J) - X(L) * A(J,L)
  800 CONTINUE
      RETURN
C
  900 PRINT 999
      ERR = 1.0
      RETURN
  901 PRINT 997
      ERR = 1.0
      RETURN
  997 FORMAT ('1ERROR IN CLIN EQ, MATRIX IS SINGULAR')
  998 FORMAT (' CAUTION-',
     $ ' CLIN EQ HAS DECOMPOSED AN ILL-CONDITIONED MATRIX.',/,
     $ ' RESULTS WILL HAVE RELATIVE ERROR =',E11.2)
  999 FORMAT ('1ERROR IN CLIN EQ, MATRIX SIZE GREATER THAN 50')
      END

@PRT,T GRNDMCA.
```

MORFITT*GRNDMCA(1) ELEMENT TABLE

D	NAME	VERSION	TYPE	DATE	TIME	SEQ #	SIZE-PRE,	TEXT	(CYCLE	WORD)		PSRMODE	LOCATION
	HTINTL		FOR SYMB	29 MAR 79	09:34:28	1		64	5	0	1		1792
	HTINTL		RELOCATABLE	29 MAR 79	09:34:36	2	3	148				QTR	1856
	MCSTEP		FOR SYMB	29 MAR 79	09:34:47	3		29	5	0	1		2007
	MCSTEP		RELOCATABLE	29 MAR 79	09:34:49	4	3	28				QTR	2036
	MDHNKL		FOR SYMB	29 MAR 79	09:34:52	5		71	5	0	1		2067
	MDHNKL		RELOCATABLE	29 MAR 79	09:34:57	6	2	93				QTR	2138
	MAGANG		FOR SYMB	29 MAR 79	09:34:57	7		4	5	0	1		2233
	MAGANG		RELOCATABLE	29 MAR 79	09:34:58	8	2	4				QTR	2237
	AXISM		FOR SYMB	29 MAR 79	09:35:04	9		67	5	0	1		2243
	AXISM		RELOCATABLE	29 MAR 79	09:35:05	10	2	31				QTR	2310
	CLINEQ		FOR SYMB	29 MAR 79	09:35:08	11		63	5	0	1		2343
	CLINEQ		RELOCATABLE	29 MAR 79	09:35:10	12	2	46				QTR	2406
	MCPLTS		FOR SYMB -Q	09 JAN 80	12:50:18	13		33	5	0	1		2454
	MCPLTS		RELOCATABLE	09 JAN 80	12:50:19	14	3	36				QTR	2487
	MCPLT2		FOR SYMB -Q	09 JAN 80	12:50:21	15		20	5	0	1		2526
	MCPLT2		RELOCATABLE	09 JAN 80	12:50:22	16	3	20				QTR	2546
	MAIN		FOR SYMB -Q	10 JAN 80	08:48:16	17		122	5	0	1		2569
	MAIN		RELOCATABLE	10 JAN 80	08:48:27	18	6	105				QTR	2691
	MCFLD		FOR SYMB -Q	15 JAN 80	10:24:04	19		63	5	0	1		2802
	MCFLD		RELOCATABLE	15 JAN 80	10:24:16	20	4	55				QTR	2865
	MCFLD2		FOR SYMB -Q	15 JAN 80	10:24:30	21		58	5	0	1		2924
	MCFLD2		RELOCATABLE	15 JAN 80	10:24:49	22	4	51				QTR	2982
	PGM		MAP SYMB	15 JAN 80	10:24:51	23		1	5	0	1		3037
	PGM		ABSOLUTE	15 JAN 80	10:24:51	24		676				QTR	3038

NEXT AVAILABLE LOCATION- 3714

ASSEMBLER PROCEDURE TABLE EMPTY

COBOL PROCEDURE TABLE EMPTY

FORTRAN PROCEDURE TABLE EMPTY

ENTRY POINT TABLE EMPTY

@BRKPT PRINTS$

APPENDIX 2

FORTRAN LISTING OF THE ARBNMC COMPUTER PROGRAM

```
MORFITT*ARBNMCA(1).MAIN
      C  SIMPLIFIED MODE CONVERSION MODEL MODIFIED TO CALCULATE FIELDS        00000100
      C  FOR AN ANTENNA OF ARBITRARY HEIGHT AND ORIENTATION.                  00000200
      C                                                                       00000300
            IMPLICIT REAL *8(A-H,O-Z)                                         00000400
            COMMON/FIRST C/ IFIRST
            COMMON/AXISM C/XTIC,YTIC,NTICX,NTICY
            COMMON/PSPLOT/PHSMIN,PHSINC,SIZEP,PTIC,NTICP
            COMMON/ICOMP C/ICOMP,ICMPMX
            COMMON/ITXRX C/ITXRX
            COMMON/SINCOS/STHTAH,CTHTAH                                       00000700
            COMMON/TYPPLT/IPLTOP
            COMMON/HTGN/F(3,20,2)                                             00000900
            COMMON/HGTEMP/FF1(20),FF3(20)                                     00001000
            COMMON/INT C/INTFLG,IPRNTA
            COMMON/TERM/NT,NTR                                                00001300
            COMMON/MMODS C/ MAXMDS                                            00001400
            COMMON/MCINPT/FOFR(20),XVAL(50),FREQ,
          $ XTRA(3,3,20),TOPHT(50),RHOMAX,RHOMIN,DELRHO,DELTAX,               00001600
          $    EPSR,SIGMA,NRSLAB,NRMODE,NTMAX,PRMODE,NTRMDS                   00001700
            COMMON/MCSTOR/A(20,20 ),S(20   ),C(20   ),KVRADT,KVRATT,AVRKOT,   00001800
          &    AVRKTT,NTHSQ,CONST,OMEGA,WAVENO                                00001900
            COMMON/PLOT V/ISUB,JPLOT,NRP,IDPLOT(10),NAPLOT,NPPLOT
            COMMON/XPLOT/XMIN,XINC,YMIN,YINC,SIZEX,SIZEY                      00002200
            COMMON/HGINPT/GAMMA(4),PHI(4),TALT,RALT                           00002
          $ ,SINGAM(4),COSGAM(4),SINPHI(4),COSPHI(4)                          00002400
      C                                                                       00002500
            COMPLEX*16 STHTA,THETAH,STHTAH(20),CTHTAH(20)                     00002600
            COMPLEX*16 ZERO/(0.0D0,0.0D0)/,ONE/(1.0D0,0.0D0)/                 00002700
            COMPLEX*16       A,S,C,FOFR,IM
            COMPLEX*16 XTRA,F                                                 00002900
            COMPLEX*16 TP(20),RATIO(4),TMP1,TMP2,TMP3,TMP4                    00003000
            COMPLEX*16 FF1,FF3                                                00003100
      C                                                                       00003200
            DIMENSION BUFFER(2000)                                            00003300
            DIMENSION BCD(20)                                                 00003400
            DIMENSION Z(2)                                                    00003500
            DIMENSION INCL(4),THETA(4)
      C                                                                       00003600
            REAL*8 NTHSQ                                                      00004000
            REAL*8 KVRADT,KVRATT                                              00004100
            REAL*8 INCL
            REAL*4           XMIN,XINC,YMIN,YINC,SIZEX,SIZEY
            REAL*4 FACT
            REAL*4 XTIC,YTIC
            REAL*4 SIZEP,PHSMIN,PHSINC,PTIC
            CHARACTER*4 BCD,NAME,EXEC,INPT,QUIT                               00003700
      C                                                                       00003800
      C                                                                       00004200
            INTEGER HFLAG                                                     00004300
```

```
      INTEGER PRMODE,RCDOPT,CNVSCF                                      00004400
C                                                                       00004500
      EQUIVALENCE(INCL,GAMMA),(THETA,PHI)
C
C                                                                       00004800
      NAMELIST/DATUM/TOPHT,RHOMAX,NPRINT,RCDOPT,H,IH,                   00004900
     $         DELRHO,INTFLG,       IPLTOP,IPRNTA,ITXRX,ICOMP,ICMPMX,
     &   RHOMIN,DELTAX,NTMAX,XVAL,
     $     FACT,NAPLOT,NPPLOT,
     $     PHSMIN,PHSINC,SIZEP,PTIC,NTICP,
     $   XMIN,XINC,YMIN,YINC,SIZEX,SIZEY,XTIC,YTIC,NTICX,NTICY,
     * GAMMA,PHI,INCL,THETA,TALT,RALT,NRP
C                                                                       00005400
      DATA NAME/4HNAME/,INPT/4HDATA/,EXEC/4HSTAR/,QUIT/4HQUIT/          00005500
      DATA DTR/0.01745329252D0/                                         00005600
      DATA TWOPI/6.283185D0/,VELITE/2.997928D5/,ALPHA/3.14D-4/,         00005700
     $  DEGRAD/1.745329D-2/,IM/(0.0D0,1.0D0)/                           00005800
C                                                                       00005900
C-----------------------------------------------------------------------00006000
C
      FACT=1.0
      SIZEX=10.0
      SIZEY=8.0
      XMIN=0.0
      YMIN=0.0
      XINC=1000.0
      YINC=10.0
      XTIC=1.0
      YTIC=1.0
      NTICX=1
      NTICY=1
      SIZEP=8.0
      PHSMIN=0.0
      PHSINC=90.0
      NTICP=1
      PTIC=2.0
C                                                                       00006100
      ISOLNA=0
      ICOMP=1
      ICMPMX=3
      ITXRX=0
      IPRNTA=0
      NRP=1                                                             00006300
      DO 8 I=1,4                                                        00006400
      GAMMA(I)=0.0D0                                                    00006500
    8 PHI(I)=0.0D0                                                      00006600
      RALT=0.0                                                          00006700
      TALT=0.0                                                          00006800
      DELTAX=0.0D0                                                      00006900
      NTMAX=1                                                           00007000
```

```
      IPLTOP=0                                                          00007100
      IH=1                                                              00007200
      H=50.0D0                                                          00007300
      CNVSCF=0                                                          00007500
      RCDOPT=0                                                          00007700
      NAPLOT=1
      NPPLOT=0
      JPLOT=0
      INTFLG=0                                                          00007900
      MAXMDS = 20                                                       00008000
      MXSLAB=50                                                         00008100
      IFIRST =1                                                         00008200
      NPRINT=1
C-----------------------------------------------------------------------00008400
C                                                                       00008500
      PRINT 199                                                         00008600
   10 PRINT 200                                                         00008700
      READ(5,201,END=999) BCD                                           00008800
   11 PRINT 202,BCD                                                     00008900
      IF(BCD(1) .EQ. NAME) GO TO 12                                     00009000
      IF(BCD(1) .EQ. INPT) GO TO 20                                     00009100
      IF(BCD(1) .EQ. EXEC) GO TO 30                                     00009200
      IF(BCD(1) .EQ. QUIT) GO TO 999                                    00009300
      GO TO 910                                                         00009400
C-----------------------------------------------------------------------00009500
C                                                                       00009600
C     READ NAMELIST                                                     00009700
   12 READ(5,201,END=999) BCD                                           00009800
      IF(SUBSTR(BCD(1),1,1) .NE. ' ') GO TO 13                          00009900
      WRITE(30,201) BCD                                                 00010000
      WRITE(6,202) BCD                                                  00010100
      GO TO 12                                                          00010200
   13 REWIND 30                                                         00010300
      DO 15 L = 1,MXSLAB                                                00010400
      XVAL(L) = 0.0D0                                                   00010500
   15 TOPHT(L)=0.0D0
C                                                                       00010700
      CALL CHK$OF                                                       00010800
      READ(30,DATUM)                                                    00010900
      CALL CHK$ON                                                       00011000
      IF(IPLTOP .LT. 1) GO TO 909                                       00011100
C
      IF(IPLTOP .LT. 2) GO TO 16
      NTMAX=1
      DELTAX=0.0
      RHOMIN=DELRHO
   16 CONTINUE
C
      IF(NAPLOT .EQ. 1 .OR. NPPLOT .EQ. 1) JPLOT=1
      IF(JPLOT     .NE. 0 .AND. IFIRST .NE. 0)CALL PLOTS(BUFFER,2000,15)00011200
```

```
      IF(JPLOT     .NE. 0 .AND. IFIRST .NE. 0)CALL PLOT(0.0,-11.0,-3)
      IF(JPLOT     .NE. 0 .AND. IFIRST .NE. 0)CALL FACTOR(FACT)
      CAPK=(1.0D0-0.5D0*ALPHA*H)                                        00011300
      Z(1) = TALT                                                       00011400
      Z(2) = RALT                                                       00011500
      DO 223 N=1,NRP                                                    00011 00
      GAMMA(N) = GAMMA(N)*DEGRAD                                        00011700
      PHI(N) = PHI(N)*DEGRAD                                            00011800
      SINGAM(N) = DSIN(GAMMA(N))                                        00011900
      COSGAM(N) = DCOS(GAMMA(N))                                        00012000
      SINPHI(N) = DSIN(PHI(N))                                          00012100
      COSPHI(N) = DCOS(PHI(N))                                          00012200
  223 CONTINUE
      REWIND 30                                                         00012500
      GO TO 11                                                          00012600
C                                                                       00012700
C-----------------------------------------------------------------------00012800
C                                                                       00012900
C     READ NPUNCH=1 DATA                                                00013000
C                                                                       00013100
   20 READ(5,203,END=915) IDPLOT                                        00013200
      PRINT 204,IDPLOT                                                  00013300
      RHO=-1.0                                                          00013400
      ISLAB=0                                                           00013500
C                                                                       00013600
C        READ IN A SLAB FROM INPUT DATA                                 00013700
C                                                                       00013800
   21 READ(5,1020,END=915) RR,FF,AA,CC,BB,SS,EE,TH                      00013900
      ISLAB=ISLAB+1                                                     00014000
      IF(RR .NE. 40.  .AND. SS .EQ. 0.) GO TO 21                        00014100
      IF(RR .EQ. 40) GO TO 25                                           00014200
C-----------------------------------------------------------------------00014300
C                                                                       00014400
C        OPTION TO USE R-CARDS FOR 'XVAL(ISLAB)' VALUES                 00014500
C          (FOR 'IPLTOP=2' OPTION ONLY)                                 00014600
      IF(RCDOPT .EQ. 0) GO TO 28                                        00014700
      IF(IPLTOP .EQ. 2) XVAL(ISLAB) = RR*1000.0
   28 CONTINUE                                                          00014900
C-----------------------------------------------------------------------00015000
C                                                                       00015100
      NTHSQ=1.0+ALPHA*TOPHT(ISLAB)                                      00015200
      IF(TOPHT(ISLAB) .EQ. 0.0D0) NTHSQ=1.0D0+ALPHA*TH                  00015300
      BB=BB*10000.                                                      00015400
      PRINT 1022,ISLAB,RR,FF,AA,CC,BB,SS,EE,TH                          00015500
      IF(NPRINT .GE. 3) PRINT 1024                                      00015600
      FREQ=FF                                                           00015700
      IF(ISLAB .NE. 1) GO TO 22                                         00015800
      WAVE NO = TWO PI*1000.0*FREQ/VELITE                               00015900
      CONST = 0.03248*WAVE NO/DSQRT(FREQ)                               00016000
      OMEGA = TWO PI*FREQ*1000.                                         00016100
```

```
      KVRAOT = DEXP(DLOG(WAVE NO/ALPHA)/3.)                             00016200
      KVRATT = KVRAOT**2                                                00016300
      AVRKOT = 1./KVRAOT                                                00016400
      AVRKTT = AVRKOT**2*0.5                                            00016500
   22 CONTINUE                                                          00016600
      IF(RHO .GT. RR) GO TO 912                                         00016700
      RHO=RR                                                            00016800
      EPSR=EE                                                           00016900
      SIGMA=SS                                                          00017000
C                                                                       00017100
C-----------------------------------------------------------------------00017200
C         READ IN T-CARDS FOR EACH SLAB                                 00017300
C                                                                       00017400
      NM=0                                                              00017500
   23 READ(5,1023,END=915) INDX1,TR1,TI1,ITRM1,TMP1,TMP2                00017600
      IF(TR1 .EQ. 0.) GO TO 24                                          00017700
      READ(5,1023,END=915) INDX2,TR2,TI2,ITRM2,TMP3,TMP4                00017800
      IF(NM .EQ. 20) GO TO 233                                          00017900
      IF(CDABS(TMP1) .EQ. 0.0D0) GO TO 233                              00018000
      IF(TR1 .NE. TR2 .OR. TI1 .NE. TI2) GO TO 234                      00018100
      IF(ITRM1 .NE. ITRM2) GO TO 234                                    00018200
      IF(ITRM1 .EQ. 0) GO TO 911                                        00018300
      NM=NM+1                                                           00018400
      IF(NPRINT .LT. 3) GO TO 230                                       00018500
      PRINT 1025,NM,INDX1,TR1,TI1,ITRM1,TMP1,TMP2,                      00018600
     $              INDX2,TR2,TI2,ITRM2,TMP3,TMP4                       00018700
  230 TP(NM)=DCMPLX(TR1,TI1)                                            00018800
      S(NM)=CDSIN(TP(NM)*DTR)                                           00018900
      C(NM)=CDCOS(TP(NM)*DTR)                                           00019000
      STHTA=S(NM)*CAPK                                                  00019100
      THETAH=-IM*CDLOG(CDSQRT(1.0D0-STHTA**2)+IM*STHTA)                 00019200
      STHTAH(NM)=CDSIN(THETAH)                                          00019300
      CTHTAH(NM)=CDCOS(THETAH)                                          00019400
      IF(IH .EQ. 0) STHTAH(NM)=S(NM)                                    00019500
      IF(IH .EQ. 0) CTHTAH(NM)=C(NM)                                    00019600
C                                                                       00019700
      XTRA(1,1,NM) = TMP1*STHTAH(NM)**2                                 00019800
      XTRA(1,2,NM) = TMP1*STHTAH(NM)                                    00019900
      XTRA(1,3,NM) = -TMP3*STHTAH(NM)                                   00020000
      XTRA(2,2,NM) = -TMP1                                              00020200
      XTRA(2,3,NM) = TMP3                                               00020300
      XTRA(2,1,NM) = -TMP1*STHTAH(NM)                                   00020100
      XTRA(3,1,NM) = -TMP3*TMP4*STHTAH(NM)                              00020400
      XTRA(3,2,NM) = -TMP3*TMP4                                         00020500
      XTRA(3,3,NM) = TMP2                                               00020600
      RATIO(2*INDX1-1)=TMP1                                             00020700
      RATIO(2*INDX1  )=TMP2                                             00020800
      RATIO(2*INDX2-1)=TMP3                                             00020900
      RATIO(2*INDX2  )=TMP4                                             00021000
      IF(ITRM1 .EQ. 2) GO TO 231                                        00021100
```

```
      FOFR(NM)=RATIO(3)/RATIO(1)                                        00021200
      GO TO 232                                                         00021300
  231 FOFR(NM)=RATIO(2)/(RATIO(3)*RATIO(4))                             00021400
  232 CONTINUE                                                          00021500
      GO TO 23                                                          00021600
  233 IF(NPRINT .LT. 3) GO TO 23                                        00021700
  234 PRINT 1026, INDX1,TR1,TI1,ITRM1,TMP1,TMP2,                        00021800
     $            INDX2,TR2,TI2,ITRM2,TMP3,TMP4                         00021900
      IF(TR1 .NE. TR2 .OR. TI1 .NE. TI2) GO TO 916                      00022000
      IF(ITRM1 .NE. ITRM2) GO TO 917                                    00022100
   24 IF(NPRINT .LT. 3) PRINT 1027,NM                                   00022200
      NRMODE=NM                                                         00022300
C                                                                       00022400
C-----------------------------------------------------------------------00022500
C                                                                       00022600
C         SPECIAL HEIGHT GAIN CALCULATION TO COMPUTE (D11,D12,D22)      00022700
C         WHERE(  (D11=FF1*FF1), (D12=FF1*FF3) ,AND (D22=FF3*FF3) )     00022800
C         FOR 'H' NOT NECESSARLY EQUAL TO ZERO.                         00022900
C                                                                       00023000
      HFLAG=1                                                           00023100
      CALL HTGAIN(Z,H,HFLAG)                                            00023200
C                                                                       00023300
      DO 136 K=1,NRMODE                                                 00023400
      XTRA(1,1,  K) = XTRA(1,1,  K)* FF1( K)**2                         00023500
      XTRA(1,2,  K) = XTRA(1,2,  K)* FF1( K)**2                         00023600
      XTRA(1,3,  K) = XTRA(1,3,  K)* FF1( K)* FF3(K)/FOFR(K)            00023700
      XTRA(2,1,  K) = XTRA(2,1,  K)* FF1( K)**2                         00023800
      XTRA(2,2,  K) = XTRA(2,2,  K)* FF1( K)**2                         00023900
      XTRA(2,3,  K) = XTRA(2,3,  K)* FF1( K)* FF3(K)/FOFR(K)            00024000
      XTRA(3,1,  K) = XTRA(3,1,  K)* FF1( K)* FF3(K)/FOFR(K)            00024100
      XTRA(3,2,  K) = XTRA(3,2,  K)* FF1( K)* FF3(K)/FOFR(K)            00024200
      XTRA(3,3,  K) = XTRA(3,3,  K)* FF3( K)**2/(FOFR(K)**2)            00024300
136   CONTINUE                                                          00024400
C                                                                       00024500
C-----------------------------------------------------------------------00024600
C                                                                       00024700
C         COMPUTE HEIGHT GAINS FOR EACH SLAB AT BOTH TALT AND RALT HEIGHT00024800
C     THIS CALL GIVES VALUES FOR FF1(K),FF3(K),F(1,K,TALT),F(2,K,TALT), 00024900
C         F(3,K,TALT),F(1,K,RALT),F(2,K,RALT),F(3,K,RALT)               00025000
C         FOR K = 1,NRMODE                                              00025100
C                                                                       00025200
      HFLAG=0                                                           00025300
      CALL HTGAIN(Z,H,HFLAG)                                            00025400
C                                                                       00025500
C-----------------------------------------------------------------------00025600
C                                                                       00025700
C         WRITE SLAB INFORMATION ON TO UNIT 9                           00025800
C                                                                       00025900
      WRITE(9) ISLAB,S,C,TP,XTRA,FOFR,NRMODE,NTHSQ,SIGMA,EPSR,F         00026000
C                                                                       00026100
```

```
C-----------------------------------------------------------------------00026200
C                                                                       00026300
C          READ IN A NEW SLAB FROM FROM INPUT DATA                      00026400
C                                                                       00026500
      GO TO 21                                                          00026600
C-----------------------------------------------------------------------00026700
C                                                                       00026800
   25 NRSLAB = ISLAB-1                                                  00026900
      IF(NRSLAB .LE. 1) GO TO 914                                       00027000
      GO TO 10                                                          00027100
C-----------------------------------------------------------------------00027200
C                                                                       00027300
   30 CONTINUE                                                          00027400
C                                                                       00027500
C          ALL SLABS HAVE BEEN READ IN                                  00027600
C                                                                       00027700
      REWIND 9                                                          00027800
      REWIND 4
C                                                                       00027900
C-----------------------------------------------------------------------00028000
C     IF THE CONVERSION COEFFICIENTS HAVE ALREADY BEEN COMPUTED         00028100
C     ------SKIP TO STATEMENT 117-----                                  00028200
      IF(CNVSCF .GT. 0) GO TO 117                                       00028300
C                                                                       00028400
C-----------------------------------------------------------------------00028500
C          COMPUTE THE CONVERSION COEFFICIENTS FOR EACH INPUT SLAB      00028600
C                                                                       00028700
      DO 555 M=1,NRSLAB                                                 00028800
C
      READ (9) ISLAB,S,C,TP,XTRA,FOFR,NRMODE,NTHSQ,SIGMA,EPSR,F         00028900
C                                                                       00029000
      IFLG=1                                                            00029800
      IF(M .EQ. 1) IFLG=0                                               00029900
      CALL HTINTL(IFLG, M,INTFLG)                                       00030000
  555 CONTINUE                                                          00030100
C                                                                       00030200
C          CONVERSION COEFFICIENTS HAVE BEEN STORED ON UNIT 4            00030300
C                                                                       00030400
      REWIND 9                                                          00030500
      REWIND 4
C                                                                       00030600
  117 CONTINUE                                                          00030700
C-----------------------------------------------------------------------00030800
C                                                                       00030900
C                                                                       00031100
C          COMPUTE FIELD STRENGTH                                       00031200
C                                                                       00031300
      IF(ISOLNA .GT. 0) GO TO 500
C
      CALL ACCUMA
```

```
C                                                                          00017000
  500 CONTINUE
C
      REWIND 10
C
      CALL MCFLD                                                           00031400
C                                                                          00031600
C--------------------------------------------------------------------------00031700
      IFIRST =0                                                            00031800
      ISOLNA=1
      CNVSCF=1                                                             00031900
      REWIND 4
      REWIND 8
      REWIND 9                                                             00032000
      REWIND 10
      GO TO 10                                                             00032100
C--------------------------------------------------------------------------00032200
C                                                                          00032300
C     ERROR EXITS                                                          00032400
  909 PRINT 1909                                                           00032500
      GO TO 999                                                            00032600
  910 PRINT 1910                                                           00032700
      GO TO 999                                                            00032800
  911 PRINT 1911                                                           00032900
      GO TO 999                                                            00033000
  912 PRINT 1912                                                           00033100
      GO TO 999                                                            00033200
  914 PRINT 1914                                                           00033300
      GO TO 999                                                            00033400
  915 PRINT 1915                                                           00033500
      GO TO 999                                                            00033600
  916 PRINT 1916                                                           00033700
      GO TO 999                                                            00033800
  917 PRINT 1917                                                           00033900
C                                                                          00034000
 1909 FORMAT('0*****  FIELD STRENGTH OPTION (IPLTOP) WAS NOT SET ')        00034100
 1910 FORMAT('0*****  ERROR IN CONTROL CARD')                              00034200
 1911 FORMAT('0*****  THIS DATA DECK IS MISSING THE FOFR FLAG IN 20')      00034300
 1912 FORMAT('0*****  XVALS OUT OF ORDER')                                 00034400
 1914 FORMAT('0*****  NUMBER OF SLABS LESS THAN 2')                        00034500
 1915 FORMAT('0*****  END OF DATA SET ON UNIT 5')                          00034600
 1916 FORMAT('0*****  ERROR IN DATA SEQUENCE')                             00034700
 1917 FORMAT('0*****  ITERM FLAG INCONSISTENT')                            00034800
C                                                                          00034900
  199 FORMAT('1')                                                          00035000
  200 FORMAT(' ')                                                          00035100
  201 FORMAT(20A4)                                                         00035200
  202 FORMAT(' ',20A4)                                                     00035300
  203 FORMAT(10A4)                                                         00035400
  204 FORMAT(' ',10A4)                                                     00035500
```

```
1001 FORMAT('0END OF JOB')
1020 FORMAT(1X,F7.0,3(2X,F8.0),2(2X,E10.0),2(2X,E5.0))
1022 FORMAT('0SLAB ',I2,' R',F7.3,' F',F8.4,' A',F8.3,' C',F8.3,' M',
   $ F6.3,' S',1PE10.3,' E',0PF5.1,' T',F5.1)
1023 FORMAT(I1,2F9.0,I1,4E15.0)
1024 FORMAT(/11X,' M  ID    THETA''')
1025 FORMAT(11X,I2,3X,I1,0P2F10.2,I2,2(1X,1P2E16.8)/
   $    16X,          I1,0P2F10.2,I2,2(1X,1P2E16.8))
1026 FORMAT(16X,      I1,0P2F10.2,I2,2(1X,1P2E16.8)/
   $    16X,          I1,0P2F10.2,I2,2(1X,1P2E16.8))
1027 FORMAT('+',80X,' MODES',I3)
 999 CONTINUE
     REWIND 9
     PRINT 1001
     IF(JPLOT .EQ. 1) CALL PLOT(0.,0.,999)
     STOP
     END

@PRT,S ARBNMCA.HTGAIN
```

```
MORFITT*ARBNMCA(1).HTGAIN
            SUBROUTINE HTGAIN(Z,H,HFLAG)
      C
      C  COMPUTE EZ,EX,EY HEIGHT GAINS FOR TRANSMITTER AND RECEIVER.
      C
            IMPLICIT COMPLEX*16(A-H,O-Z)
            COMMON/SINCOS/STHTAH,CTHTAH
            COMMON/HGTEMP/FF1(20),FF3(20)
            COMMON/HTGN/F(3,20,2)
            COMMON/MCINPT/FOFR(20),XVAL(50),FREQ,
           $ XTRA(3,3,20),TOPHT(50),RHOMAX,RHOMIN,DELRHO,DELTAX,
           $    EPSR,SIGMA,NRSLAB,NRMODE,NTMAX,PRMODE,NTRMDS
            COMMON/MCSTOR/A(20,20 ),S(20  ),C(20   ),KVRAOT,KVRATT,AVRKOT,
           &    AVRKTT,NTHSQ,CONST,OMEGA,WAVENO
      C
            COMPLEX*16 CDSQRT
            COMPLEX*16 NGSQ,IM/(0.D0,1.D0)/
            COMPLEX*16 STHTAH(20),CTHTAH(20)
      C
            REAL*8 DEXP
            REAL*8 NTHSQ
            REAL*8 XVAL,FREQ,RHOMAX,RHOMIN,DELRHO,DELTAX,EPSR,  SIGMA
            REAL*8 KVRAOT,KVRATT,AVRKOT,AVRKTT,CONST,OMEGA,WAVENO
            REAL*8 Z(2),EPSLNO/8.85434D-12/,ALPHA/3.14D-4/,FAC1
            REAL*8 RSQR
            REAL*8 TOPHT
            INTEGER HFLAG
            INTEGER PRMODE
      C
            NGSQ = EPSR-(IM*SIGMA/OMEGA)/EPSLNO
            KH=1
            IF(HFLAG .EQ. 0) KH=2
            DO 100 K=1,NRMODE
            SSQ = S(   K)**2
            IF(HFLAG .EQ. 1) SSQ=STHTAH(K)**2
            SQROOT = CDSQRT(NGSQ-SSQ)
            CSQ = C(   K)**2
            IF(HFLAG .EQ. 1) CSQ=CTHTAH(K)**2
            RSQR = SQROOT
            IF(RSQR .LT. 0.) SQROOT=-SQROOT
            DO 100 IZ=1,KH
            IF(HFLAG .EQ. 0) Q=KVRATT*(CSQ+ALPHA*Z(IZ))
            IF(HFLAG .EQ. 0) CALL MDHNKL(Q,H1,H2,H1PRM,H2PRM)
            IF(HFLAG .EQ. 0) Q0=KVRATT*CSQ
            IF(HFLAG .EQ. 1) Q0=KVRATT*(CSQ-ALPHA*H)
            CALL MDHNKL(Q0,H10,H20,H1PRM0,H2PRM0)
            CAPH10 = H1PRM0+AVRKTT*H10
            CAPH20 = H2PRM0+AVRKTT*H20
            FAC2 = IM*KVRAOT*SQROOT
            FAC3 = FAC2/NGSQ
```

```
      IF(HFLAG .EQ. 1) FAC3=FAC3*(1.0D0-ALPHA*H)
      F1 = -(CAPH20-FAC3*H20)
      F2 =   CAPH10-FAC3*H10
      F3 = -(H2PRM0-FAC2*H20)
      F4 =   H1PRM0-FAC2*H10
      FAC1 = DEXP(ALPHA/2.*Z(IZ))
      FF1(  K) = F1*H10+F2*H20
      FF3(  K) = F3*H10+F4*H20
      IF(HFLAG .EQ. 1) GO TO 99
      F(1,  K,IZ) = FAC1*(F1*H1+F2*H2)
      F(2,  K,IZ) = ALPHA/(IM*2.*WAVENO)*F(1,  K,IZ)+1./IM*AVRKOT*FAC1*
     $ (F1*H1PRM+F2*H2PRM)
      F(3,  K,IZ) = F3*H1+F4*H2
      F(1,  K,IZ) = F(1,  K,IZ)/FF1(  K)
      F(2,  K,IZ) = F(2,  K,IZ)/FF1(  K)
      F(3,  K,IZ) = F(3,  K,IZ)*FOFR(  K)/FF3(  K)
   99 CONTINUE
  100 CONTINUE
      RETURN
      END
```

@PRT,S ARBNMCA.HTINTL

MORFITT*ARBNMCA(1).HTINTL

```
      SUBROUTINE HTINTL(IFLG,M,INTFLG)                                  00000100
C                                                                       00000200
      IMPLICIT REAL *8(A-H,O-Z)                                         00000300
C                                                                       00000400
      COMMON/NPRNT C/NPRINT                                             00000600
      COMMON/MMODS C/ MAXMDS                                            00000700
      COMMON/HTGN/F(3,20,2)                                             00000800
      COMMON/MCINPT/FOFR(20),XVAL(50),FREQ,
     $ XTRA(3,3,20),TOPHT(50),RHOMAX,RHOMIN,DELRHO,DELTAX,              00001000
     $    EPSR,SIGMA,NRSLAB,NRMODE,NTMAX,PRMODE,NTRMDS                  00001100
      COMMON/MCSTOR/A(20,20 ),S(20  ),C(20   ),KVRAOT,KVRATT,AVRKOT,    00001200
     &    AVRKTT,NTHSQ,CONST,OMEGA,WAVENO                               00001300
C                                                                       00001400
      COMPLEX*16 F                                                      00001500
      COMPLEX*16 INORM(20,20)                                           00001600
      COMPLEX*16 PTHA,H1TA,H2TA,H1PRTA,H2PRTA,HYTHA(20),EYTHA(20),      00001700
     $ HYTHPA(20),EYTHPA(20)                                            00001800
      COMPLEX*16        FOFR,A,S,C,SSQ,CSQ,IM/(0.0D0,1.0D0)/,NGSQ,      00001900
     &    SQROOT,RTIORT,P0,PTH,H10,H20,H1PRM0,H2PRM0,CAPH10,CAPH20,     00002000
     &  A1ST,A2ND,A3RD,A4TH,DEN12,DEN34,DENMF,NURMF,                    00002100
     &    H1T,H2T,H1PRMT,H2PRMT,HYTH(20),EYTH(20),HYTHPR(20),EYTHPR(20), 00002200
     &    HYOPR(20),EYOPR(20),EYO(20),MULT,FAC1,FAC2,NORM(20,20),PS(20), 00002300
     $    CAPI(20,20),PHYTH(20),PHYTHP(20),PEYTH(20),PEYTHP(20),        00002400
     $    PEYO(20),PEYOPR(20),PHYOPR(20),XTRA                           00002500
      COMPLEX*16 ZERO/(0.0D0,0.0D0)/,ONE/(1.0D0,0.0D0)/                 00002600
C                                                                       00002700
      REAL*8 NTHSQ,NTHSQP                                               00002800
      REAL*8 KVRAOT,KVRATT                                              00002900
      REAL * 4 ERR                                                      00003000
      INTEGER PRMODE                                                    00003100
C                                                                       00003200
      DATA EPSLN0/8.85434D-12/                                          00003300
C                                                                       00003400
C                                                                       00003500
      DO 5 K=1,MAXMDS                                                   00003600
      DO 5 J=1,MAXMDS                                                   00003700
    5 INORM(J,K)=ZERO                                                   00003800
C-----------------------------------------------------------------------00003900
C                                                                       00004000
      DO 100 K = 1, NRMODE                                              00004100
      SSQ = S(K)**2                                                     00004200
      CSQ = C(K)**2                                                     00004300
      NGSQ =     EPSR    -(IM*SIGMA    /OMEGA)/EPSLN0                   00004400
      SQROOT = CDSQRT(NGSQ - SSQ)                                       00004500
      RSQR = SQROOT                                                     00004600
      IF(RSQR .LT. 0.) SQROOT=-SQROOT                                   00004700
      RTIORT = 1./NGSQ*SQROOT                                           00004800
      P0 = KVRATT*CSQ                                                   00004900
      PTH = KVRATT*(NTHSQ   -SSQ)                                       00005000
```

```
      CALL MDHNKL(P0,H10,H20,H1PRMO,H2PRMO)                             00005100
      CAPH10 = H1PRMO + AVRKTT*H10                                      00005200
      CAPH20 = H2PRMO + AVRKTT*H20                                      00005300
      A1ST = CAPH20 - IM*RTIORT*KVRAOT*H20                              00005400
      A2ND = CAPH10 - IM*RTIORT*KVRAOT*H10                              00005500
      A3RD = H2PRMO - IM*KVRAOT*SQROOT*H20                              00005600
      A4TH = H1PRMO - IM*KVRAOT*SQROOT*H10                              00005700
      DEN12 = H20*A2ND - H10*A1ST                                       00005800
      DEN34 = H20*A4TH - H10*A3RD                                       00005900
      CALL MDHNKL(PTH,H1T,H2T,H1PRMT,H2PRMT)                            00006000
C                                                                       00006100
      HYTH(K) = (H2T*A2ND - H1T*A1ST)/DEN12                             00006200
      EYTH(K) = (H2T*A4TH - H1T*A3RD)/DEN34*FOFR(   K)                  00006300
      HYTHPR(K) = (H2PRMT*A2ND - H1PRMT*A1ST)/DEN12                     00006400
      EYTHPR(K) = (H2PRMT*A4TH - H1PRMT*A3RD)/DEN34*FOFR(   K)          00006500
      HYOPR(K) = (H2PRMO*A2ND - H1PRMO*A1ST)/DEN12                      00006600
      EYOPR(K) = (H2PRMO*A4TH - H1PRMO*A3RD)/DEN34*FOFR(   K)           00006700
C                                                                       00006800
      IF(IFLG .EQ. 0) GO TO 100                                         00006900
C-----------------------------------------------------------------------00007000
C                                                                       00007100
C     NOT FIRST SLAB                                                    00007200
C                                                                       00007300
      PTHA = KVRATT*(NTHSQP     -SSQ)                                   00007400
      CALL MDHNKL(PTHA,H1TA,H2TA,H1PRTA,H2PRTA)                         00007500
      HYTHA(K) = (H2TA*A2ND-H1TA*A1ST)/DEN12                            00007600
      EYTHA(K) = (H2TA*A4TH-H1TA*A3RD)/DEN34*FOFR(   K)                 00007700
      HYTHPA(K) = (H2PRTA*A2ND-H1PRTA *A1ST)/DEN12                      00007800
      EYTHPA(K) = (H2PRTA*A4TH-H1PRTA*A3RD)/DEN34*FOFR(   K)            00007900
C                                                                       00008000
  100 EYO(K) = FOFR(   K)                                               00008100
C                                                                       00008200
C-----------------------------------------------------------------------00008300
C     COMPUTE NORM(J,K) FOR ALL SLABS                                   00008500
C                                                                       00008600
      IF(INTFLG .EQ. 1) PRINT 906,M                                     00008700
      DO 240 J = 1,NRMODE                                               00008800
      DO 240 K = 1,NRMODE                                               00008900
      IF(J .EQ. K) GO TO 120                                            00009000
      MULT = AVRKOT/((S(   J) - S(   K))*WAVENO)                        00009100
      FAC1 = EYTH(K)*EYTHPR(J) - EYTH(J)*EYTHPR(K) + HYTH(K)*HYTHPR(J)  00009200
     $     -HYTH(J)*HYTHPR(K)                                           00009300
      FAC2 = -EYO(K)*EYOPR(J) + EYO(J)*EYOPR(K) - HYOPR(J) + HYOPR(K)   00009400
      NORM(   J,K) = MULT*(FAC1+FAC2)                                   00009500
      IF(INTFLG .EQ. 0) GO TO 240                                       00009600
      CALL MAGANG( NORM(J,K),AMAGG,ANGG)                                00009700
      PRINT 908,M,J,K,NORM(J,K),AMAGG,ANGG                              00009800
      GO TO 240                                                         00009900
  120 MULT = 2.0*S(   J)*KVRAOT/WAVENO                                  00010000
      PTH = KVRATT*(NTHSQ    -S(   J)**2)                               00010100
```

```
       PO = KVRATT*C(   J)**2
      FAC1 = EYTHPR(J)**2 + HYTHPR(J)**2 + PTH*(EYTH(J)**2 + HYTH(J)**2)
      FAC2 = -EYOPR(J)**2 - HYOPR(J)**2 - PO*(EYO(J)**2 + 1.0)
      NORM(  J,K) = MULT*(FAC1+FAC2)
      IF(INTFLG .EQ. 0) GO TO 240
      CALL MAGANG( NORM(J,K),AMAGG,ANGG)
      PRINT 908,M,J,K,NORM(J,K),AMAGG,ANGG
  240 CONTINUE
C----------------------------------------------------------------------
C
C     FOR FIRST SLAB ONLY
C
      IF (IFLG  .NE. 0) GO TO 500
      PRMODE = NRMODE
      DO 602 K   =1,NRMODE
      PS(K )   = S(K   )
      DO 602 J   =1,NRMODE
  602 INORM(J   ,K   )=ZERO
      GO TO 850
C
C----------------------------------------------------------------------
C
C     COMPUTE CAPI(K,J) AND INORM(K,J) FOR ALL SLABS
C     EXCEPT THE FIRST
C
  500 CONTINUE
      DO 400 K = 1, NRMODE
      DO 400 J = 1, PRMODE
      MULT = AVRKOT/((PS(J) - S(  K))*WAVENO)
      FAC1 = EYTHA(K)*PEYTHP(J)-PEYTH(J)*EYTHPA(K)
     $+HYTHA(K)*PHYTHP(J)-PHYTH(J)*HYTHPA(K)
      FAC2 = -EYO(K)*PEYOPR(J) + PEYO(J)*EYOPR(K) -PHYOPR(J) + HYOPR(K)
      CAPI(  K,J) = MULT*(FAC1+FAC2)
      IF(INTFLG .EQ. 0) GO TO 400
      CALL MAGANG( CAPI(K,J),AMAGG,ANGG)
      PRINT 910,M,K,J,CAPI(K,J),AMAGG,ANGG
  400 CONTINUE
C
      INIT = 0
      DO 700 J = 1,PRMODE
      CALL CLINEQ(NORM ,CAPI (1,J),INORM(1,J  ),NRMODE,MAXMDS,INIT,ERR)
      INIT = 1
      IF(ABS(ERR) .GT. 0.01)   PRINT 701,ERR,J
  701 FORMAT('0','  ERR = ',F5.0,'          J = ',I3)
  700 CONTINUE
C
C----------------------------------------------------------------------
  850 CONTINUE
C
      WRITE(4)     M,INORM,S,C,PS,FOFR,XTRA,NRMODE,PRMODE,F
```

```
      C                                                                 00015200
      C-----------------------------------------------------------------00015300
      C                                                                 00015400
      C     PREVIOUS SLAB VARIABLES                                     00015500
      C                                                                 00015600
            DO 600 J = 1, NRMODE                                        00015700
            PS(J) = S(  J)                                              00015800
            PHYTH(J) = HYTH(J)                                          00015900
            PHYTHP(J) = HYTHPR(J)                                       00016000
            PEYTH(J) = EYTH(J)                                          00016100
            PEYTHP(J) = EYTHPR(J)                                       00016200
            PHYOPR(J) = HYOPR(J)                                        00016300
            PEYO(J) = EYO(J)                                            00016400
            PEYOPR(J) = EYOPR(J)                                        00016500
        600 CONTINUE                                                    00016600
            PRMODE=NRMODE                                               00016700
            NTHSQP=NTHSQ                                                00016800
      C                                                                 00016900
      C-----------------------------------------------------------------00017000
            IF(INTFLG .LT. 1) GO TO 42                                  00017100
            PRINT 900,M                                                 00017200
            DO 450 K=1,PRMODE                                           00017300
            DO 450 J=1,NRMODE                                           00017400
            CALL MAGANG(INORM(J,K),AMAGG,ANGG)                          00017500
            PRINT 901,J,K,INORM(J,K),AMAGG,ANGG                         00017600
        450 CONTINUE                                                    00017700
         42 CONTINUE                                                    00017800
      C                                                                 00017900
      C-----------------------------------------------------------------00018200
            RETURN                                                      00018000
      C                                                                 
        900 FORMAT(1H0,14X,                                             00018300
           $ ' INORM = NORMALIZED CONVERSION COEFFICIENTS',             00018400
           $                                    6X,'SLAB NUMBER = ',I2,/) 00018500
      901   FORMAT(' J =',I2,2X,' K =',I2,2X,' INORM = ',(1PE15.5,1PE15.5), 00018600
           $2X, 1PE15.5,0PF9.2,/)                                       00018700
      906   FORMAT('0INTEGRALS IN SLAB',I3,/)                           00018800
      908   FORMAT(' NORM(',I2,',',I2,',',I2,') =',2E13.6,              00018900
           $10X,1PE15.5,0PF10.2)                                        00019000
      910   FORMAT(' CAPI(',I2,',',I2,',',I2,') =',2E13.6,              00019100
           $10X,1PE15.5,0PF10.2)                                        00019200
      C                                                                 00018100
            END                                                         00019900
```

@PRT,S ARBNMCA.ACCUMA

```
MORFITT*ARBNMCA(1).ACCUMA
      SUBROUTINE ACCUMA
C                                                                       00000200
C       'IPLTOP = 1'                                                    00000300
C     COMPUTE FIELDS FROM XVAL MIN TO XVAL MAX FOR TWO XMTR-RCVR DISTANCES00000400
C     AT DELTAX INTERVALS                                               00000500
C                                                                       00000600
C       'IPLTOP = 2'                                                    00000700
C     COMPUTE FIELDS FROM RHO MIN TO RHO MAX                            00000800
C     AT DEL RHO INTERVALS.                                             00000900
C                                                                       00001000
        IMPLICIT REAL *8(A-H,O-Z)                                       00001100
C                                                                       00001200
        COMMON/PREVAC/PREVA
        COMMON/TERM/NT,NTR
        COMMON /MAXES/MAXCNT,MAXDSK
        COMMON/ICOMP C/ICOMP,ICMPMX
        COMMON/ITXRX C/ITXRX
        COMMON/TYPPLT/IPLTOP                                            00001500
        COMMON/SNTR C/SNTR                                              00001600
        COMMON/INORM C/INORM                                            00001800
        COMMON /PREV C/ PS                                              00001900
        COMMON/PLOT V/ISUB,JPLOT,NRP,IDPLOT(10)
        COMMON/MCINPT/FOFR(20),XVAL(50),FREQ,
      $ XTRA(3,3,20),TOPHT(50),RHOMAX,RHOMIN,DELRHO,DELTAX,             00002500
      $    EPSR,SIGMA,NRSLAB,NRMODE,NTMAX,PRMODE,NTRMDS                 00002600
        COMMON/MCSTOR/A(20,20 ),S(20  ),C(20  ),KVRAOT,KVRATT,AVRKOT,   00002700
      &    AVRKTT,NTHSQ,CONST,OMEGA,WAVENO                              00002800
        COMMON/HGINPT/GAMMA(4),PHI(4),TALT,RALT                         00002900
      $ ,SINGAM(4),COSGAM(4),SINPHI(4),COSPHI(4)                        00003000
C                                                                       00003100
C                                                                       00003300
        COMPLEX*16 ASNTRK
        COMPLEX*16 STORA(20,20)
        COMPLEX*16 PREVA(20,20)                                         00003400
        COMPLEX*16 F(3,20,2)                                            00003500
        COMPLEX*16 SOLNA(20,3,4),      A,S,C,XTRA,TB,TDBL,TA,FOFR       00003600
        COMPLEX*16 PS(20),IM/(0.0D0,1.0D0)/                             00003700
        COMPLEX*16 EXCNTR(3,3,20),SNTR(20),FNTR(3,20,2)                 00003800
        COMPLEX*16 INORM(20,20)                                         00003900
        COMPLEX*16 ZERO/(0.0D0,0.0D0)/                                  00004000
        COMPLEX*16 ONE/(1.0D0,0.0D0)/
C                                                                       00004100
        REAL*4 TERMDS,RSTART,RTEMP,RSTOP
        REAL*8 KVRAOT,KVRATT                                            00004300
        REAL*8 NTHSQ                                                    00004400
        INTEGER PRMODE                                                  00004500
C                                                                       00004600
        DATA ERAD/6.370D3/                                              00004700
        DATA DTR/0.01745329252D0/                                       00004800
```

```
C
      NT=1
      ICOUNT=0
C                                                                       00005200
      IF(IPLTOP .GT. 1) XVAL(1)=0.0
C-----------------------------------------------------------------------00005300
C                                                                       00005400
C        IDENTIFY THE SLAB WHICH CONTAINS THE TRANSMITTER (I.E. NTR)    00005500
C                                                                       00005600
  118 CONTINUE                                                          00005700
C                                                                       00005800
      REWIND 4
      REWIND 8
C                                                                       00006300
      IF(XVAL(2) .GE. 0.0) GO TO 111                                    00006400
      DO 113 L=3,NRSLAB                                                 00006500
      IF(XVAL(L) .GE. 0.0) GO TO 114                                    00006600
  113 CONTINUE                                                          00006700
      NTR = NRSLAB                                                      00006800
      GO TO 120                                                         00006900
  114 NTR=L-1                                                           00007000
      GO TO 120                                                         00007100
  111 NTR = 1                                                           00007200
  120 CONTINUE                                                          00007300
C                                                                       00007400
      IF(ITXRX .LT. 1) GO TO 804
      PRINT 800,NTR                                                     00007500
  800 FORMAT('0',' THE TRANSMITTER IS IN SLAB NO. ',I5/)                00007600
      PRINT 801                                                         00007700
  801 FORMAT(' ',10X,' XVAL(I) = ')                                     00007800
      DO 802  I = 1,NRSLAB                                              00007900
  802 PRINT 803,XVAL(I)                                                 00008000
  803 FORMAT(20X,F10.3/)                                                00008100
  804 CONTINUE
C                                                                       00008400
C-----------------------------------------------------------------------
C
C     READ IN TRANSMITTER SLAB
C
   10 CONTINUE
C
      READ (4) NSLAB,INORM,S,C,PS,FOFR,XTRA,NRMODE,PRMODE,F             00009300
C
      M = NSLAB
      IF(NSLAB .LT. NTR) GO TO 10
      IF(NSLAB .NE. NTR) GO TO 11
C
      NTRMDS=NRMODE                                                     00008600
C                                                                       00008700
      DO 12 N=1,3                                                       00009600
```

```
      DO 12 L=1,3
      DO 12 K=1,NTRMDS                                                  00009800
      EXCNTR(N,L,K) = XTRA(N,L,K)                                       00009900
      SNTR(K) = S(K)                                                    00010000
      FNTR(L,K,1) = F(L,K,1)                                            00010100
   12 CONTINUE                                                          00011000
   11 CONTINUE
C
C-----------------------------------------------------------------------00011200
C                                                                       00011300
      CALL MCSTEP(NTR)                                                  00011400
C                                                                       00011500
C-----------------------------------------------------------------------00011600
C                                                                       00011700
      IF(IPLTOP .GT. 1) GO TO 753                                       00011800
      MSAVED=NTR                                                        00011900
      DO 750 M=1,NTR                                                    00012000
      DO 751 J=1,NRMODE                                                 00012100
      DO 751 K=1,NTRMDS                                                 00012200
      IF(M .NE. NTR) STORA(J,K)=ZERO                                    00012300
      IF(M .EQ. NTR) STORA(J,K)=A(J,K)
  751 CONTINUE                                                          00012500
      WRITE(8)          M,STORA,NRMODE,NTRMDS,S,F
  750 CONTINUE                                                          00012700
C
  753 CONTINUE                                                          00012800
C                                                                       00012900
C-----------------------------------------------------------------------00013000
      IF(IPLTOP .LT. 2) M=0
      LOOP=0                                                            00013200
C                                                                       00013300
   91 CONTINUE                                                          00013600
C                                                                       00013500
      IF(LOOP .GT. 0) MS=MSAVED
C                                                                       00013700
      ISUB = 1                                                          00013800
      RHO = RHO MIN                                                     00013900
      IDSFLG = 0
      IDSCNT = 0
C                                                                       00014000
  600 CONTINUE                                                          00014100
C                                                                       00014200
C-----------------------------------------------------------------------00014300
C
      IF(ITXRX .LT. 1) GO TO 5559
      PRINT 5556,RHO
 5556 FORMAT('0','RHO = ',F10.2)
 5559 CONTINUE
C                                                                       00014400
C         IDENTIFY THE SLAB WHICH CONTAINS THE RECEIVER (I.E. NRX )     00014500
```

```
C                                                                       00015100
      IF((XVAL(2) - RHO) .GE. 0.0) GO TO 511                            00015200
      DO 513 I=3,NRSLAB                                                 00015300
      IF((XVAL(I) - RHO) .GE. 0.0) GO TO 514                            00015400
  513 CONTINUE                                                          00015500
      NRX = NRSLAB                                                      00015600
      GO TO 520                                                         00015700
  514 NRX=I-1                                                           00015800
      GO TO 520                                                         00015900
  511 NRX = 1                                                           00016000
  520 CONTINUE                                                          00016100
C                                                                       00016200
      IF(ITXRX .LT. 1) GO TO 504
      PRINT 500,NRX                                                     00016300
  500 FORMAT('0',' THE RECEIVER    IS IN SLAB NO. ',I5/)                00016400
      PRINT 501                                                         00016500
  501 FORMAT(' ',10X,' XVAL(I) = ')                                     00016600
      DO 502  I = 1,NRSLAB                                              00016700
  502 PRINT 503,XVAL(I)                                                 00016800
  503 FORMAT(20X,F10.3/)                                                00016900
  504 CONTINUE
C                                                                       00017200
C-----------------------------------------------------------------------00017300
C                                                                       00017400
      IF(IPLTOP .LT. 2) GO TO 9000
      IF(IDSFLG .LT. 1) GO TO 9100
      IF(M .EQ. NRX) GO TO 720
      IDSCNT = IDSCNT+1
      RSTOP = RTEMP-DELRHO
C
      WRITE(10) RSTART,RSTOP,NTR,NRMODE,M,XVALM,S,F,SOLNA
C
      IDSFLG = 0
C
 9000 CONTINUE
C
C-----------------------------------------------------------------------00017300
C
C     THE VARIABLE ''LOOP = 1''  INDICATES THAT THE SLAB CONTAINING     00017500
C     THE TRANSMITTER HAS NOT CHANGED.                                  00017600
C                                                                       00017700
      IF(LOOP .NE. 1) GO TO 752                                         00017800
      IF(RHO .GT. RHOMIN) GO TO 755
C
  142 IF(NRX .EQ. MS) GO TO 143
      MS=MS-1
      MSAVED=MS
      BACKSPACE 8
      GO TO 142                                                         00018300
  143 CONTINUE                                                          00018400
```

```
      BACKSPACE 8
      READ (8)        MS,PREVA,NRMODE,NTRMDS,S,F
      DO 132 J=1,NRMODE                                                 00018600
      DO 132 K=1,NTRMDS                                                 00018700
  132 A(J,K)=PREVA(J,K)                                                 00018800
C
      MR=MS
C
      GO TO 20                                                          00018900
  755 CONTINUE
      IF(MS .EQ. NRX) GO TO 720
  754 IF(M .LE. MS) GO TO 51
      M=M-1
      BACKSPACE 4
      GO TO 754
  752 CONTINUE                                                          00019000
C                                                                       00019100
C-----------------------------------------------------------------------00019200
C                                                                       00019300
      IF(M .EQ. NRX) GO TO 720                                          00019400
      IF(LOOP .EQ. 1) GO TO 51                                          00019500
 9100 CONTINUE
      IF(NSLAB .EQ. NTR) M=NTR                                          00019600
      IF(NSLAB .NE. NTR) M=NSLAB                                        00019700
   51 CONTINUE                                                          00019800
      IF(M .EQ. NTR  .AND.  NTR .EQ. NRX) MR=M
      IF(M .EQ. NTR  .AND.  NTR .EQ. NRX) GO TO 20                      00019900
C                                                                       00030700
C-----------------------------------------------------------------------00017100
C                                                                       00020000
C        READ IN A NEW SLAB                                             00020100
C                                                                       00020200
   22 CONTINUE
      M=M+1                                                             00020400
C                                                                       00020500
      READ (4) NSLAB,INORM,S,C,PS,FOFR,XTRA,NRMODE,PRMODE,F             00009300
C                                                                       00020700
      CALL MCSTEP(M)                                                    00020300
C                                                                       00020900
C-----------------------------------------------------------------------00021000
C                                                                       00021100
      IF(IPLTOP .GT. 1) GO TO 131                                       00021200
      IF(RHO .GT. RHOMIN) GO TO 131                                     00021300
      MSAVED=M                                                          00021700
      WRITE(8)         M,    A,NRMODE,NTRMDS,S,F
C
  131 CONTINUE                                                          00021900
C                                                                       00022000
C-----------------------------------------------------------------------00022100
C                                                                       00022200
```

```
      IF(M .NE. NRX) GO TO 22
      MR=M
C                                                                       00023100
C-----------------------------------------------------------------------00023200
C                                                                       00023300
   20 CONTINUE                                                          00023400
C                                                                       00023500
      DO 710 N=1,NRP                                                    00023600
      DO 710 L=1,ICMPMX
      DO 710  J = 1,NRMODE                                              00023800
      SOLN A(J,L,N) = (0.0,0.0)                                         00023900
      DO 710  K = 1,NTRMDS                                              00024000
      IF(L .EQ. 1) ASNTRK=(ONE/SNTR(K) )
      IF(L .NE. 1) ASNTRK= ONE
      IF(MR .NE. NTR) GO TO 35
      SOLN A(J,L,N) = SOLN A(J,L,N)                                     00024200
     *             +A(J,K)*((EXCNTR(1,L,K)          )*FNTR(1,K,1)*
     $COSGAM(N)+ EXCNTR(2,L,K)*FNTR(2,K,1)*SINGAM(N)*                   00024500
     $COSPHI(N)+ EXCNTR(3,L,K)*FNTR(3,K,1)*SINGAM(N)*                   00024600
     $SINPHI(N)) *ASNTRK
      GO TO 710                                                         00025000
C
35    SOLN A(J,L,N) = SOLN A(J,L,N)                                     00025100
     *             +A(J,K)*((EXCNTR(1,L,K)          )*FNTR(1,K,1)*
     $COSGAM(N)+ EXCNTR(2,L,K)*FNTR(2,K,1)*SINGAM(N)*                   00025400
     $COSPHI(N)+ EXCNTR(3,L,K)*FNTR(3,K,1)*SINGAM(N)*                   00025500
     $SINPHI(N)) *ASNTRK                                                00025600
     $  *CDEXP(-IM*WAVENO*SNTR(K)*XVAL(NTR+1))                           00025700
C
  710 CONTINUE                                                          00026000
      IDSFLG = 1
      RSTART = RHO
C                                                                       00026100
C-----------------------------------------------------------------------00026200
C                                                                       00026300
  720 CONTINUE                                                          00026400
C
C-----------------------------------------------------------------------
C
      ICOUNT=ICOUNT+1
      IF(ICOUNT .GT. 402) GO TO 999
C
      XVALM=XVAL(NRX)
      IF(IPLTOP .GT. 1) GO TO 888
      TERMDS=XVAL(2)
C
      WRITE(10) ISUB,NT,NTR,NRMODE,NRX,TERMDS,RHO,XVALM,S,F,SOLNA
C
  888 CONTINUE
 8089 CONTINUE
```

```
C
C-----------------------------------------------------------------------
C
      RHO = RHO + DEL RHO                                               00030300
      RTEMP = RHO
      ISUB = ISUB+1                                                     00030400
      IF (RHO.LE.RHO MAX)  GO TO 600                                    00030500
C                                                                       00030E00
      ISUB = ISUB-1                                                     00030800
      MAXCNT=ICOUNT
      IF(IPLTOP .LT. 2) GO TO 105
C
C-----------------------------------------------------------------------00017300
C
      RSTOP = RTEMP - DELRHO
      IDSCNT = IDSCNT+1
      WRITE(10) RSTART,RSTOP,NTR,NRMODE,M,XVALM,S,F,SOLNA
C
      MAXDSK=IDSCNT
      RETURN
C
C-----------------------------------------------------------------------00017300
C
  999 PRINT 998,ICOUNT
  998 FORMAT('0','THE PROGRAM STOPS--ICOUNT = ',I6,
     *'  IS GREATER THAN 402')
      GO TO 997
C
C------------------------------------------------------------------
C
  105 CONTINUE
      NT=NT+1
      IF(NT .GT. NTMAX) GO TO 833
      DO 106 ME=1,NRSLAB                                                00035300
106   XVAL(ME) = XVAL(ME)+DELTAX                                        00035400
C                                                                       00035500
C-----------------------------------------------------------------------00036100
C                                                                       00036200
C     CHECK TO SEE IF A SLAB BOUNDRY HAS MOVED PAST THE TRANSMITTER     00036300
C                                                                       00036400
      IF(XVAL(NTR) .GE. 0. .AND. NT .LE. NTMAX) GO TO 118               00036500
      IF(NT .GT. NTMAX) GO TO 833                                       00036600
C                                                                       00036700
C     THE VARIABLE ''LOOP = 1''  INDICATES THAT THE SLAB CONTAINING     00036800
C     THE TRANSMITTER HAS NOT CHANGED.                                  00036900
C                                                                       00037000
      LOOP=1                                                            00037100
      GO TO 91                                                          00037200
  833 CONTINUE                                                          00037300
      NT=NT-1
```

```
      C                                                                 00037400
            RETURN                                                      00037500
      C                                                                 00035100
  997       CONTINUE
            STOP
            END

@PRT,S ARBNMCA.MCSTEP
```

```
MORFITT*ARBNMCA(1).MCSTEP
      SUBROUTINE MCSTEP(M)                                              00000100
C                                                                       00000200
      IMPLICIT REAL *8(A-H,O-Z)                                         00000300
      COMMON/PREVAC/PREVA
      COMMON/HTGN/F(3,20,2)                                             00000400
      COMMON/SNTR C/SNTR                                                00000500
      COMMON/INT C/INTFLG,IPRNTA
      COMMON/NPRNT C/NPRINT                                             00000700
      COMMON /PREV C/ PS                                                00000800
      COMMON/INORM C/INORM                                              00000900
      COMMON/TERM/NT,NTR                                                00001000
      COMMON/MCINPT/FOFR(20),XVAL(50),FREQ,
     $ XTRA(3,3,20),TOPHT(50),RHOMAX,RHOMIN,DELRHO,DELTAX,              00001200
     $    EPSR,SIGMA,NRSLAB,NRMODE,NTMAX,PRMODE,NTRMDS                  00001300
      COMMON/MCSTOR/A(20,20 ),S(20  ),C(20  ),KVRAOT,KVRATT,AVRKOT,     00001400
     &    AVRKTT,NTHSQ,CONST,OMEGA,WAVENO                               00001500
C                                                                       00001600
      COMPLEX*16 PS(20),PREVA(20,20),SNTR(20)                           00001800
      COMPLEX*16 INORM(20,20)                                           00001900
      COMPLEX*16        FOFR,A,S,C,
     $  IM/(0.0D0,1.0D0)/,B(20),XTRA                                    00002100
C                                                                       00002200
      REAL*8 NTHSQ                                                      00002300
      REAL*8 KVRAOT,KVRATT                                              00002400
      INTEGER PRMODE                                                    00002500
C                                                                       00002600
      MP=M-1                                                            00002700
      IF(M .NE. NTR) GO TO 50                                           00002800
      DO 32 K=1,NTRMDS                                                  00002900
      DO 32 J=1,NRMODE                                                  00003000
      IF(J .EQ. K) GO TO 31                                             00003100
      A(J,K) = (0.0D0,0.0D0)                                            00003200
      GO TO 32                                                          00003300
   31 A(J,K) = (1.0D0,0.0D0)                                            00003400
   32 CONTINUE                                                          00003500
      GO TO 24                                                          00003600
C                                                                       00003700
C-----------------------------------------------------------------------00003800
C                                                                       00003900
C     FOR SLAB(M) NOT EQUAL TO SLAB(NTR)                                00004000
C                                                                       00004100
   50 CONTINUE                                                          00004200
      DO 17 N = 1,NRMODE                                                00004300
   17 B(N) = (0.,0.)                                                    00004400
      IF(MP .EQ. NTR) GO TO 21                                          00004500
C                                                                       00004600
C-----------------------------------------------------------------------00004700
C                                                                       00004800
C     FOR SLAB(MP) NOT EQUAL TO SLAB(NTR)                               00004900
```

```
      C                                                                 00005000
            DO 29 K = 1,NTRMDS                                          00005100
            DO 33 L = 1,NRMODE                                          00005200
            DO 33 J = 1,PRMODE                                          00005300
         33 B(L) = B(L)+INORM(L,J   )*CDEXP(-IM*WAVENO*   PS(J)*(XVAL(M)-  00005400
          $   XVAL(MP) ))*PREVA(J,K)                                    00005500
            DO 27 I = 1,NRMODE                                          00005600
         27 A(   I,K) =    B(I)                                          MORFITT
      C  27 A(   I,K) =    B(I)*S(I)/SNTR(K)                             PAPPERT
            DO 18 N=1,NRMODE                                            00005900
      18    B(N) = (0.,0.)                                              00006000
         29 CONTINUE                                                    00006100
            GO TO 24                                                    00006200
      C                                                                 00006300
      C-----------------------------------------------------------------00006400
      C                                                                 00006500
      C     FOR SLAB(MP) EQUAL TO SLAB(NTR)                             00006600
      C                                                                 00006700
         21 DO 23 K = 1,NTRMDS                                          00006800
            DO 25 L = 1,NRMODE                                          00006900
         25 B(L) = INORM(L,K   )                                        00007000
            DO 35 J = 1,NRMODE                                          00007100
         35 A(   J,K) =    B(J)                                          MORFITT
      C  35 A(   J,K) =    B(J) *S(J)/SNTR(K)                            PAPPERT
         23 CONTINUE                                                    00007400
         24 CONTINUE                                                    00007500
      C                                                                 00007600
      C-----------------------------------------------------------------00007700
      C                                                                 00007800
            DO 40 K=1,NTRMDS                                            00007900
            DO 40 J=1,NRMODE                                            00008000
         40 PREVA(J,K)=A(J,K)                                           00008100
      C                                                                 00008200
      C-----------------------------------------------------------------00008300
      C                                                                 00008400
            IF(IPRNTA .LT. 1) GO TO 42
            PRINT 900,M                                                 00008600
            DO 450 K = 1,NTRMDS                                         00008700
            DO 450 J = 1,NRMODE                                         00008800
            CALL MAGANG(A(J,K),AMAGG,ANGG)                              00008900
            PRINT 901,J,K,A(   J,K),AMAGG  "GG                          00009000
        450 CONTINUE                                                    00009100
        900 FORMAT(1H ,14X,                                             00009200
          $ 'A = TOTAL CONVERSION COEFFICIENTS',6X,'SLAB NUMBER = ',I2,/)  00009300
      901   FORMAT(' J =',I2,2X,' K =',I2,2X,' A = ',(1PE15.5,1PE15.5),  00009400
          $2X, 1PE15.5,0PF9.2,/)                                        00009500
         42 CONTINUE                                                    00009600
      C                                                                 00009700
            RETURN                                                      00009800
            END                                                         00009900
```

@PRT,S ARBNMCA.MCFLD

MORFITT*ARBNMCA(1).MCFLD

```
      SUBROUTINE MCFLD                                                  00000100
C                                                                       00000200
C       'IPLTOP = 1'                                                    00000300
C     COMPUTE FIELDS FROM XVAL MIN TO XVAL MAX FOR TWO XMTR-RCVR DISTANCES00000400
C     AT DELTAX INTERVALS                                               00000500
C                                                                       00000600
C       'IPLTOP = 2'                                                    00000700
C     COMPUTE FIELDS FROM RHO MIN TO RHO MAX                            00000800
C     AT DEL RHO INTERVALS.                                             00000900
C                                                                       00001000
      IMPLICIT REAL *8(A-H,O-Z)                                         00001100
C                                                                       00001200
      COMMON/FIRST C/ IFIRST
      COMMON /MAXES/MAXCNT,MAXDSK
      COMMON/ICOMP C/ICOMP,ICMPMX
      COMMON/ITXRX C/ITXRX
      COMMON/TYPPLT/IPLTOP                                              00001500
      COMMON/SNTR C/SNTR                                                00001600
      COMMON/INORM C/INORM                                              00001800
      COMMON /PREV C/ PS                                                00001900
      COMMON/SPLOT/SAVED(402),Y1(4,402),Y2(4,402)
     $,ANG1(4,402),ANG2(4,402)
      COMMON/MCPLOT/R(402),DB(4,402),ANG(4,402)
      COMMON/PLOT V/ISUB,JPLOT,NRP,IDPLOT(10),NAPLOT,NPPLOT
      COMMON/MCINPT/FOFR(20),XVAL(50),FREQ,
     $ XTRA(3,3,20),TOPHT(50),RHOMAX,RHOMIN,DELRHO,DELTAX,              00002500
     $    EPSR,SIGMA,NRSLAB,NRMODE,NTMAX,PRMODE,NTRMDS                  00002600
      COMMON/MCSTOR/A(20,20 ),S(20  ),C(20  ),KVRAOT,KVRATT,AVRKOT,     00002700
     &    AVRKTT,NTHSQ,CONST,OMEGA,WAVENO                               00002800
      COMMON/HGINPT/GAMMA(4),PHI(4),TALT,RALT                           00002900
     $ ,SINGAM(4),COSGAM(4),SINPHI(4),COSPHI(4)                         00003000
C                                                                       00003300
      COMPLEX*16 PREVA(20,20)                                           00003400
      COMPLEX*16 F(3,20,2)                                              00003500
      COMPLEX*16 SOLNA(20,3,4),TAP,  A,S,C,XTRA,TB,TDBL,TA,FOFR         00003600
      COMPLEX*16 PS(20),IM/(0.0D0,1.0D0)/                               00003700
      COMPLEX*16 EXCNTR(3,3,20),SNTR(20),FNTR(3,20,2)                   00003800
      COMPLEX*16 INORM(20,20)                                           00003900
      COMPLEX*16 ZERO/(0.0D0,0.0D0)/                                    00004000
C                                                                       00004100
      REAL*8 KVRAOT,KVRATT                                              00004300
      REAL*8 NTHSQ                                                      00004400
      REAL*4 TERMDS,RSTART,RTEMP,RSTOP
      REAL*4 R,DB,ANG,SAVED,Y1,Y2
      REAL*4 ANG1,ANG2
      INTEGER PRMODE                                                    00004500
C
      DATA ERAD/6.370D3/                                                00004700
      DATA DTR/0.0174532925200/                                         00004800
```

```
C                                                                       00004900
C-----------------------------------------------------------------------00005000
C                                                                       00005400
      L=ICOMP
C
      IF(IPLTOP .GT. 1) GO TO 300
C
C-----------------------------------------------------------------------00005000
C                                                                       00004900
C     IPLTOP =1
C                                                                       0C031600
C     THIS SECTION COMPUTES THE FIELDS AS A FUNCTION OF THE DISTANCE    00031400
C     BETWEEN THE TRANSMITTER AND THE TERMINATOR.   ALSO THE FIELDS ARE 00031500
C     COMPUTED     FROM XVAL MIN TO XVAL MAX FOR TWO XMTR-RCVR DISTANCES00031600
C   AT DELTAX INTERVALS                                                 00031700
C
      NTMAX2=2*NTMAX
      I=0
  100 CONTINUE
      I=I+1
      IF(I .GT. NTMAX2) GO TO 350
C
      READ(10)  ISUB,NT,NTR,NRMODE,M,TERMDS,RHO,XVALM,S,F,SOLNA
C
      GO TO 400
C
C-------------------------------------------------------------------------------
C
C     IPLTOP=2
C                                                                       00038100
C     THIS SECTION COMPUTES THE FIELDS AS A FUNCTION OF THE DISTANCE    00038200
C     BETWEEN THE TRANSMITTER AND THE RECEIVER.     ALSO THE FIELDS ARE 00038300
C   AT DEL RHO INTERVALS.                                               00038400
C     COMPUTED     FROM RHO MIN TO RHO MAX                              00038500
C
  300 CONTINUE
      I=1
      ISUB=I
      IDSKRD = 1
  500 CONTINUE
      READ (10) RSTART,RSTOP,NTR,NRMODE,M,XVALM,S,F,SOLNA
C
      RHO=RSTART
C                                                                       00017800
C-------------------------------------------------------------------------------
C
  400 CONTINUE
C
      DO 900 N=1,NRP                                                    00026500
      TA = (0.0,0.0)                                                    00026700
```

```
      DO 730  J = 1,NRMODE                                          00026800
      IF(M   .NE. NTR) GO TO 45                                     00026900
      TB =CDEXP(-IM*WAVENO*S(J)*RHO)                                00027000
      TAP =   SOLN A(J,L,N)*TB*F(L,J,2)
      IF(L .EQ. 1) TAP=TAP*S(J)                                      MORFITT
      TA=TAP+TA
      GO TO 730                                                     00027400
C
   45 TB =CDEXP(IM*WAVENO*    S(J)*(XVALM     - RHO))               00027500
      TAP =   SOLN A(J,L,N)*TB*F(L,J,2)
      IF(L .EQ. 1) TAP=TAP*S(J)                                      MORFITT
      TA=TAP+TA
  730 CONTINUE                                                      00027900
      TA = TA*CONST/DSQRT(DSIN(RHO/ERAD))                           00028000
      TDBL = TA *CDEXP (IM * WAVE NO * RHO)                         00028100
      CALL MAGANG (TDBL, TDMAG, TDANG)                              00028200
      TSMAG = TDMAG                                                 00028300
      TSANG = TDANG                                                 00028400
      TSDB = 8.685890 * DLOG (TSMAG * 1.0E6)                        00028500
C
      R(ISUB) = RHO                                                 00028600
      DB(  N,ISUB) = TSDB
      ANG(  N,ISUB) = TSANG
C                                                                   00028900
      IF(IPLTOP .GT. 1) GO TO 899                                   00029000
      SAVED(NT)=TERMDS
C                                                                   00004600
      IF(MOD(ISUB,2) .EQ. 1) Y1(  N,NT) = DB(  N,ISUB)              00029600
      IF(MOD(ISUB,2) .EQ. 0) Y2(  N,NT) = DB(  N,ISUB)
      IF(MOD(ISUB,2) .EQ. 1) ANG1(  N,NT) = ANG(  N,ISUB)           0002
      IF(MOD(ISUB,2) .EQ. 0) ANG2(  N,NT) = ANG(  N,ISUB)
  899 CONTINUE                                                      00030000
C                                                                   00030100
900   CONTINUE                                                      00030200
C
      IF(IPLTOP .GT. 1) GO TO 250
      GO TO 100
C
C-------------------------------------------------------------------00031000
C                                                                   00031100
  250 CONTINUE
      IF(ABS(RSTOP-RSTART ) .LT. 0.0001) GO TO 800
      I=I+1
      ISUB=I
      RHO=RHO+DELRHO
      IF(RHO .LE. RSTOP) GO TO 400
  800 IDSKRD=IDSKRD+1
      IF(IDSKRD .LE. MAXDSK) GO TO 500
      I=I-1
      IF(I .EQ. MAXCNT) GO TO 670
```

```
      PRINT 671,I,MAXCNT
  671 FORMAT('0','DISTANCE COUNT ERROR FOR (IPLTOP = 2).',/
     $ '  I = ',I6,'  MAXCNT = ',I6,'  PROGRAM STOPS' )
      GO TO 999
C
C-----------------------------------------------------------------00017700
C
C     'IPLTOP = 1'                                                00031200
C                                                                 00031300
  350 CONTINUE
      DO 930 N=1,NRP                                              00032000
      PRINT 910                                                   00032300
      GAMMA(N) = GAMMA(N)/1.745329D-2
      PGAMMA = GAMMA(N)
      PHI(N) = PHI(N)/1.745329D-2
      PPHI = PHI(N)
      PRINT 927,PGAMMA,PPHI,TALT,RALT                             00032400
      PRINT 920                                                   00032500
      IF(ICOMP .EQ. 1) PRINT 925
      IF(ICOMP .EQ. 2) PRINT 926
      IF(ICOMP .EQ. 3) PRINT 928
      DO 930 JJ=1,NTMAX                                           00032900
      PRINT 908,SAVED(JJ),Y1(  N,JJ),ANG1(  N,JJ),Y2(N,JJ),ANG2(N,JJ)
930   CONTINUE                                                    00033400
      IF(JPLOT .EQ. 0) RETURN                                     00033500
C
      IF(IFIRST .EQ. 1) CALL PLOT(1.0,1.0,-3)
      IF(NAPLOT .EQ. 1) ITYPE=1
      IF(NAPLOT .EQ. 1) CALL MCPLTS(ITYPE)
      IF(NPPLOT .EQ. 1) ITYPE=2
      IF(NPPLOT .EQ. 1) CALL MCPLTS(ITYPE)
      RETURN                                                      00033900
C                                                                 00034000
  908 FORMAT(' ',25X,F7.1,  1X,F8.3,1X,F7.2 ,25X,  1X,F8.3,1X,F7.2)
910   FORMAT('1',                                                 00034100
     $ ' ELECTRIC FIELD STRENGTH AS A FUNCTION OF TRANSMITTER-TERMINATOR00034200
     $ DISTANCE(D)',/ )
920   FORMAT('0',26X,'FIELD AT RHOMIN',34X,'FIELD AT RHOMAX')     00034400
927   FORMAT('0GAMMA(DEG)=',F6.1,' PHI(DEG)=',F6.1,' TALT(KM) = ',
     $ F10.3,'  RALT(KM) = ',F10.3/)
  925 FORMAT('0',26X,'D',5X,'EZ(DB)',2X,'EZ(ANG)',30X,
     $ 'EZ(DB)',2X,'EZ(ANG)'/)
  926 FORMAT('0',26X,'D',5X,'EX(DB)',2X,'EX(ANG)',30X,
     $ 'EX(DB)',2X,'EX(ANG)'/)
  928 FORMAT('0',26X,'D',5X,'EY(DB)',2X,'EY(ANG)'.30X,
     $ 'EY(DB)',2X,'EY(ANG)'/)
C                                                                 00034700
C-----------------------------------------------------------------00034800
C                                                                 00034900
  670 CONTINUE                                                    00037800
```

```
C                                                                      00037900
C     'IPLTOP = 2'                                                     00038000
C                                                                      00005200
      DO 630 N=1,NRP                                                   00038600
      PRINT 610
      PRINT 620
  620 FORMAT('0')
      IF(ICOMP .EQ. 1) PRINT 628
      IF(ICOMP .EQ. 2) PRINT 631
      IF(ICOMP .EQ. 3) PRINT 632
      GAMMA(N) = GAMMA(N)/1.745329D-2
      PGAMMA = GAMMA(N)
      PHI(N) = PHI(N)/1.745329D-2
      PPHI = PHI(N)
      PRINT 627,PGAMMA,PPHI,TALT,RALT                                  00038900
      PRINT 629                                                        00039100
  627 FORMAT('0',11X,'GAMMA(DEG)=',F6.1,' PHI(DEG)=',F6.1,' TALT(KM)=', 00039200
     $  F10.3,' RALT(KM)=',F10.3/)
  628 FORMAT('0',22X,'EZ' )
  631 FORMAT('0',22X,'EX' )
  632 FORMAT('0',22X,'EY' )
  629 FORMAT(2X,1(9X,'RHO(KM)',3X,'AMP(DB)',3X,'ANG(DEG)')/)
      DO 630 J=1,MAXCNT
      PRINT 608,R(J),DB(   N,J),ANG(   N,J)
  630 CONTINUE                                                         00039900
      IF(JPLOT .EQ. 0) RETURN                                          00040000
C                                                                      00040100
      IF(IFIRST .EQ. 1) CALL PLOT(1.0,1.0,-3)
      IF(NAPLOT .EQ. 1) ITYPE=1
      IF(NAPLOT .EQ. 1) CALL MCPLTS(ITYPE)
      IF(NPPLOT .EQ. 1) ITYPE=2
      IF(NPPLOT .EQ. 1) CALL MCPLTS(ITYPE)
      RETURN                                                           00040400
C                                                                      00040500
  608 FORMAT(2X,1(7X,F10.2,F10.5,F10.4))
  610 FORMAT('1',10X,                                                  00040700
     $  'ELECTRIC FIELD STRENGTH AS A FUNCTION OF RHO',/ )              0
C-----------------------------------------------------------------------00040900
C                                                                      00043300
  999 CONTINUE
      STOP
      END                                                              00043400

@PRT,S ARBNMCA.MCPLTS
```

```
MORFITT*ARBNMCA(1).MCPLTS
            SUBROUTINE MCPLTS(ITYPE)
      C        FOR(IPLTOP = 1)
      C  MCPLTS GENERATES TWO PLOTS (FIELD AMPLITUDE IN DB ABOVE A
      C  MICRO VOLT PER METER FOR 1 KW RADIATED POWER VERSUS TRANSMITTER-
      C  TERMINATOR DISTANCE FOR TWO RECEIVER POSITIONS).
      C
      C        FOR(IPLTOP = 2)
      C     MCPLTS GENERATES ONE PLOT(FIELD AMPLITUDE IN DB ABOVE A MICRO VOLT
      C     PER METER FOR 1 KW RADIATED POWER VERSUS DISTANCE FROM TRANSMITTER).
      C
      C     FOR 'ITYPE = 1' PLOTS ARE GENERATED FOR AMPLITUDE VS. DISTANCE.
      C     FOR 'ITYPE = 2' PLOTS ARE GENERATED FOR PHASE(DEGREES) VS. DIST.
      C
            COMMON/AXISM C/XTIC,YTIC,NTICX,NTICY
            COMMON/TYPPLT/IPLTOP
            COMMON /MAXES/MAXCNT,MAXDSK
            COMMON/ICOMP C/ICOMP,ICMPMX
            COMMON/TERM/NT,NTR
            COMMON/PLOT V/ISUB,JPLOT,NRP,IDPLOT(10),NAPLOT,NPPLOT
            COMMON/SPLOT/SAVED(402),Y1(4,402),Y2(4,402)
           $,ANG1(4,402),ANG2(4,402)
            COMMON/MCPLOT/R(402),DB(4,402),ANG(4,402)
            COMMON/XPLOT/XMIN,XINC,YMIN,YINC,SIZEX,SIZEY                   00002200
            COMMON/PSPLOT/PHSMIN,PHSINC,SIZEP,PTIC,NTICP
            COMMON/HGINPT/GAMMA(4),PHI(4),TALT,RALT                        00002300
           $ ,SINGAM(4),COSGAM(4),SINPHI(4),COSPHI(4)                      00002400
            COMMON/MCINPT/FDFR(20),XVAL(50),FREQ,
           $ XTRA(3,3,20),TOPHT(50),RHOMAX,RHOMIN,DELRHO,DELTAX,           00001600
           $    EPSR,SIGMA,NRSLAB,NRMODE,NTMAX,PRMODE,NTRMDS               00001700
            COMMON/MCSTOR/A(20,20 ),S(20  ),C(20  ),KVRAOT,KVRATT,AVRKOT,  00001800
           &    AVRKTT,NTHSQ,CONST,OMEGA,WAVENO                            00001900
      C
      C
            COMPLEX*16 XTRA,A,S,C,FDFR
      C
            REAL*8 XVAL,FREQ,RHOMAX,RHOMIN,DELRHO,DELTAX,EPSR,SIGMA,TOPHT
            REAL*8 ZT,ZR
            REAL*8 SINGAM,COSGAM,SINPHI,COSPHI
            REAL*8 GAMMA,PHI,TALT,RALT
            REAL*8 KVRAOT,KVRATT,NTHSQ
      C
            REAL*4 R,DB,ANG,SAVED,Y1,Y2
            REAL*4 ANG1,ANG2
            REAL*4           XMIN,XINC,YMIN,YINC,SIZEX,SIZEY
            REAL*4 XTIC,YTIC
            REAL*4 SIZEP,PHSMIN,PHSINC,PTIC
      C
            REAL*4 XCURVE(2)/0.,1./,YCURV1(2)/2*.2/,YCURV2(2)/2*.4/,
           $  YCURV3(2)/2*.6/,YCURV4(2)/2*.8/
```

```
C                                                                       00037700
      COMPLEX*16 COMP(3)/'Z COMPONENT      ', 'X COMPONENT      ',
     $   'Y COMPONENT      '/
C
      INTEGER PRMODE
      DIMENSION Y(402)
      DIMENSION GAMMAD(4),PHID(4)
C
      ZT=TALT
      ZR=RALT
C
      IF(IPLTOP .GT. 1) GO TO 400
      NTOTAL=NTMAX
      NMPLTS=2
      SAVED(NTOTAL+1) = XMIN
      SAVED(NTOTAL+2) = XINC
      IF(ITYPE .EQ. 2) GO TO 401
      Y(NTOTAL+1) = YMIN
      Y(NTOTAL+2) = YINC
      WMIN = YMIN
      WINC = YINC
      WTIC = YTIC
      NTICW = NTICY
      SIZEW = SIZEY
      GO TO 402
  401 CONTINUE
      Y(NTOTAL+1) = PHSMIN
      Y(NTOTAL+2) = PHSINC
      WMIN = PHSMIN
      WINC = PHSINC
      WTIC = PTIC
      NTICW = NTICP
      SIZEW = SIZEP
  402 CONTINUE
      GO TO 450
C
  400 CONTINUE
      NTOTAL=MAXCNT
      NMPLTS=1
      R(NTOTAL+1) = XMIN
      R(NTOTAL+2) = XINC
      IF(ITYPE .EQ. 2) GO TO 403
      Y(NTOTAL+1) = YMIN
      Y(NTOTAL+2) = YINC
      WMIN = YMIN
      WINC = YINC
      WTIC = YTIC
      NTICW = NTICY
      SIZEW = SIZEY
      GO TO 404
```

```
  403 CONTINUE
      Y(NTOTAL+1) = PHSMIN
      Y(NTOTAL+2) = PHSINC
      WMIN = PHSMIN
      WINC = PHSINC
      WTIC = PTIC
      NTICW = NTICP
      SIZEW = SIZEP
  404 CONTINUE
  450 CONTINUE
C
      DO 900 I=1,NMPLTS
C
      IF(IPLTOP .EQ. 1)
     $CALL AXISM(0.0,0.0,'TRANSMITTER-TERMINATOR DISTANCE(KM)',-35,
     $ SIZEX,0.0,SAVED(NTOTAL+1),SAVED(NTOTAL+2),XTIC,NTICX)
C
      IF(IPLTOP .EQ. 2)
     $CALL AXISM(0.0,0.0,'RHO(KM)',-7,
     $ SIZEX,0.0,     R(NTOTAL+1),     R(NTOTAL+2),XTIC,NTICX)
C
C     'ITYPE = 1'
      IF(ITYPE .EQ. 1)
     *CALL AXISM(0.0,0.0,'DB ABOVE 1 UV/M FOR 1 KW',24,SIZEW,90.0,
     $ Y(NTOTAL+1),Y(NTOTAL+2),WTIC,NTICW)
C
C     'ITYPE = 2'
      IF(ITYPE .EQ. 2)
     *CALL AXISM(0.0,0.0,'PHASE(DEGREES)',14,SIZEW,90.0,
     $ Y(NTOTAL+1),Y(NTOTAL+2),WTIC,NTICW)
C
      DO 600 J=1,NRP
      GO TO (1,2,3,4),J
    1 JJ=1
      GO TO 5
    2 JJ=3
      GO TO 5
    3 JJ=5
      GO TO 5
    4 JJ=7
    5 CONTINUE
C
      DO 500 K=1,NTOTAL
C
      IF(ITYPE .EQ. 2) GO TO 300
      IF(IPLTOP .GT. 1) Y(K) = DB(J,K)
      IF(IPLTOP .LT. 2 .AND. I .EQ. 1) Y(K) = Y1(J,K)
      IF(IPLTOP .LT. 2 .AND. I .EQ. 2) Y(K) = Y2(J,K)
      GO TO 301
C
```

```
      300 CONTINUE
          IF(IPLTOP .GT. 1) Y(K) = ANG(J,K)
          IF(IPLTOP .LT. 2 .AND. I .EQ. 1) Y(K) = ANG1(J,K)
          IF(IPLTOP .LT. 2 .AND. I .EQ. 2) Y(K) = ANG2(J,K)
      301 CONTINUE
  500     CONTINUE
C
          IF(IPLTOP .EQ. 2)
         $CALL CURVE(R,     Y,NTOTAL,XMIN,WMIN,XINC,WINC,JJ)
          IF(IPLTOP .EQ. 1)
         $CALL CURVE(SAVED,Y,NTOTAL,XMIN,WMIN,XINC,WINC,JJ)
  600     CONTINUE
C
          CALL SYMBOL(0.5,(SIZEW+1.0),0.14,IDPLOT,0.0,40)
          CALL SYMBOL(0.5,(SIZEW+0.8),0.14,COMP(ICOMP),0.0,16)
          CALL SYMBOL(0.5,(SIZEW+0.6),0.14,'FREQ=',0.0,5)
          CALL NUMBER(1.4,(SIZEW+0.6),0.14,SNGL(FREQ),0.0,3)
          CALL SYMBOL(0.5,(SIZEW+0.4),0.14,'TALT =         RALT = ',0.0,21)
          CALL NUMBER(1.7,(SIZEW+0.4),0.14,SNGL(TALT),0.0,2)
          CALL NUMBER(3.7,(SIZEW+0.4),0.14,SNGL(RALT),0.0,2)
C
          IF(IPLTOP .GT. 1) GO TO 650
          CALL SYMBOL(0.5,(SIZEW+0.2),0.14,'RECEIVER DISTANCE = ',0.0,20)
          IF(I .EQ. 1) CALL NUMBER(3.4,(SIZEW+0.2),0.14,SNGL(RHOMIN),0.0,1)
          IF(I .EQ. 2) CALL NUMBER(3.4,(SIZEW+0.2),0.14,SNGL(RHOMAX),0.0,1)
      650 CONTINUE
C
          CALL SYMBOL(4.5,(SIZEW+0.8),0.14,'GAMMA=        PHI=',0.0,17)
          CALL NUMBER(5.7,(SIZEW+0.8),0.14,SNGL(GAMMA(1)),0.0,1)
          CALL NUMBER(7.2,(SIZEW+0.8),0.14,SNGL(PHI(1)),0.0,1)
          IF(NRP .LT. 2) GO TO 700
          CALL SYMBOL(4.5,(SIZEW+0.6),0.14,'GAMMA=        PHI=',0.0,17)
          CALL NUMBER(5.7,(SIZEW+0.6),0.14,SNGL(GAMMA(2)),0.0,1)
          CALL NUMBER(7.2,(SIZEW+0.6),0.14,SNGL(PHI(2)),0.0,1)
          IF(NRP .LT. 3) GO TO 700
          CALL SYMBOL(4.5,(SIZEW+0.4),0.14,'GAMMA=        PHI=',0.0,17)
          CALL NUMBER(5.7,(SIZEW+0.4),0.14,SNGL(GAMMA(3)),0.0,1)
          CALL NUMBER(7.2,(SIZEW+0.4),0.14,SNGL(PHI(3)),0.0,1)
          IF(NRP .LT. 4) GO TO 700
          CALL SYMBOL(4.5,(SIZEW+0.2),0.14,'GAMMA=        PHI=',0.0,17)
          CALL NUMBER(5.7,(SIZEW+0.2),0.14,SNGL(GAMMA(4)),0.0,1)
          CALL NUMBER(7.2,(SIZEW+0.2),0.14,SNGL(PHI(4)),0.0,1)
      700 CONTINUE
C
          CALL PLOT(8.0,SIZEW,-3)
          CALL CURVE(XCURVE,YCURV4,2,0.0,0.0,1.0,1.0,1)
          IF(NRP .LT. 2) GO TO 800
          CALL CURVE(XCURVE,YCURV3,2,0.0,0.0,1.0,1.0,3)
          IF(NRP .LT. 3) GO TO 800
          CALL CURVE(XCURVE,YCURV2,2,0.0,0.0,1.0,1.0,5)
```

```
          IF(NRP .LT. 4) GO TO 800
          CALL CURVE(XCURVE,YCURV1,2,0.0,0.0,1.0,1.0,7)
    800   CONTINUE
          CALL PLOT(-8.0,-SIZEW,-3)
C
          CALL PLOT(SIZEX+5.0,0.0,-3)
  900     CONTINUE
          RETURN
C
          END
```

@PRT,S ARBNMCA.MDHNKL

```
MORFITT*ARBNMCA(1).MDHNKL
            SUBROUTINE MDHNKL (Z,H1,H2,H1PRME,H2PRME)                           00000100
      C  COMPUTE MODIFIED HANKEL FUNCTIONS OF ORDER ONE THIRD                   00000200
            IMPLICIT REAL *8 (A-H,O-Z)                                          00000300
            COMPLEX*16 CDSQRT,CDEXP                                             00000400
            REAL*8 CDABS                                                        00000500
            COMPLEX*16 Z,I,H1,H2,H1PRME,H2PRME,ZPOWER,TERM1,TERM2,              00000600
           $          TERM3,ZTERM,TERM,SUM1,SUM2,SUM3,SUM4,SQRTZB,              00000700
           $          EXP1,EXP2,EXP3,EXP4,EXP5,GM2F,GPMFP,MPOWER,BETA,RTZ,      00000800
           $          CONST1,CONST2,CONST3,CONST4                               00000900
            DIMENSION A(23), B(23), C(23), D(23), CAP(14)                       00001000
            DATA A/                                                             00001100
           $   9.30436716930000D-01,3.10145572309700D 01,2.06763714873160D 02,00001200
           $   5.74343652425450D 02,8.70217655190080D 02,8.28778719228640D 02,00001300
           $   5.41685437404340D 02,2.57945446383020D 02,9.34584950663100D 01,00001400
           $   2.66263518707400D 01,6.12100043005600D 00,1.15928038448000D 00,00001500
           $   1.84012759441000D-01,2.48330309640000D-02,2.88420801000000D-03,00001600
           $   2.91334142000000D-04,2.58274950000000D-05,2.02568600000000D-06,00001700
           $   1.41557000000000D-07,8.87000000000000D-09,5.01000000000000D-10,00001800
           $   2.60000000000000D-11,1.00000000000000D-12/                       00001900
            DATA B/                                                             00002000
           $   6.78298725140000D-01,1.13049787524000D 01,5.38332321543100D 01,00002100
           $   1.19629404787350D 02,1.53371031778650D 02,1.27809193148880D 02,00002200
           $   7.47422182157200D 01,3.23559386215200D 01,1.07853128738400D 01,00002300
           $   2.85325737403000D 00,6.13603736351000D-01,1.09376780098000D-01,00002400
           $   1.64229399550000D-02,2.10550512200000D-03,2.33167788000000D-04,00002500
           $   2.25282890000000D-05,1.91567100000000D-06,1.44470000000000D-07,00002600
           $   9.72900000000000D-09,5.89000000000000D-10,3.20000000000000D-11,00002700
           $   2.00000000000000D-12,0.00000000000000D 00/                       00002800
            DATA C/                                                             00002900
           $   4.65218358460000D-01,6.20291144619000D 00,2.58454643591500D 01,00003000
           $   5.22130593114000D 01,6.21584039421500D 01,4.87516993663900D 01,00003100
           $   2.70842718702200D 01,1.12150194079600D 01,3.59455750255000D 00,00003200
           $   9.18150064510000D-01,1.91281263439000D-01,3.31222966990000D-02,00003300
           $   4.84244103800000D-03,6.05683682000000D-04,6.55501820000000D-05,00003400
           $   6.19859900000000D-06,5.16550000000000D-07,3.82200000000000D-08,00003500
           $   2.52800000000000D-09,1.50000000000000D-10,8.00000000000000D-12,00003600
           $   0.00000000000000D 00,0.00000000000000D 00/                       00003700
            DATA D/                                                             00003800
           $   6.78298725140000D-01,4.52199150096200D 01,3.76832625080150D 02,00003900
           $   1.19629404787350D 03,1.99382341312250D 03,2.04494709038206D 03,00004000
           $   1.42010214609865D 03,7.11830649673510D 02,2.69632821846030D 02,00004100
           $   7.98912064729000D 01,1.90217158268800D 01,3.71881052333900D 00,00004200
           $   6.07648778323000D-01,8.42202048960000D-02,1.00262146690000D-02,00004300
           $   1.03630127800000D-03,9.38678690000000D-05,7.51243500000000D-06,00004400
           $   5.35074000000000D-07,3.41350000000000D-08,1.96200000000000D-09,00004500
           $   1.02000000000000D-10,5.00000000000000D-12/                       00004600
            DATA CAP/                                                           00004700
           $   1.04166666666667D-01,8.35503472222222D-02,1.28226574556327D-01,00004800
           $   2.91849026464140D-01,8.81627267443758D-01,3.32140828186277D 00,00004900
```

```
     $    1.49957629868626D 01,7.89230130115870D 01,4.74451538868000D 02,00005000
     $    3.20749009100000D 03,2.40865496000000D 04,1.98923120000000D 05,00005100
     $    1.79190200000000D 06,1.74843770000000D 07/                    00005200
C                                                                       00005300
      DATA I/(0.D0,1.D0)/                                               00005400
      DATA ROOT3/1.73205080756888D 00/                                  00005500
      DATA ALPHA/8.53667218838951D-01/                                  00005600
      DATA CONST1/( 2.58819045102522D-01,-9.65925826289067D-01)/        00005700
      DATA CONST2/( 2.58819045102522D-01, 9.65925826289067D-01)/        00005800
      DATA CONST3/(-9.65925826289067D-01, 2.58819045102522D-01)/        00005900
      DATA CONST4/(-9.65925826289067D-01,-2.58819045102522D-01)/        00006000
C                                                                       00006100
      ZPOWER=1.0                                                        00006200
      SUM3=0.0                                                          00006300
      SUM4=0.0                                                          00006400
      ZMAG=CDABS(Z)                                                     00006500
      IF(ZMAG .GT. 4.2) GO TO 70                                        00006600
      IF(ZMAG .GE. 3.2) GO TO 10                                        00006700
      N=12                                                              00006800
      GO TO 30                                                          00006900
   10 IF(ZMAG .GE. 4.1) GO TO 20                                        00007000
      N=15                                                              00007100
      GO TO 30                                                          00007200
   20 N=23                                                              00007300
   30 SUM1=0.                                                           00007400
      SUM2=0.                                                           00007500
      ZTERM=-Z**3/200.0                                                 00007600
      DO 50 M=1,N                                                       00007700
      SUM1=SUM1+A(M)*ZPOWER                                             00007800
      SUM2=SUM2+B(M)*ZPOWER                                             00007900
      SUM3=SUM3+C(M)*ZPOWER                                             00008000
      SUM4=SUM4+D(M)*ZPOWER                                             00008100
      ZPOWER=ZPOWER*ZTERM                                               00008200
      IF(CDABS(ZPOWER) .LE. 1.0D-30) GO TO 60                           00008300
   50 CONTINUE                                                          00008400
   60 GM2F=I*(Z*SUM2-2.*SUM1)/ROOT3                                     00008500
      GPMFP=I*(SUM4+2.*Z*Z*SUM3)/ROOT3                                  00008600
      H1=Z*SUM2+GM2F                                                    00008700
      H2=H1-2.0*GM2F                                                    00008800
      H1PRME=SUM4+GPMFP                                                 00008900
      H2PRME=H1PRME-2.0*GPMFP                                           00009000
      RETURN                                                            00009100
C                                                                       00009200
   70 SUM1=1.0                                                          00009300
      SUM2=1.0                                                          00009400
      RTZ=CDSQRT(Z)                                                     00009500
      SQRTZB=RTZ*Z                                                      00009600
      ZTERM=I/SQRTZB                                                    00009700
      MPOWER=1.0                                                        00009800
      TERM=-1.5/Z                                                       00009900
```

```
      DO 80 M=1,14                                                      00010000
      ZPOWER=ZPOWER*ZTERM                                               00010100
      MPOWER=MPOWER*(-ZTERM)                                            00010200
      TERM1=CAP(M)*ZPOWER                                               00010300
      TERM2=CAP(M)*MPOWER                                               00010400
      SUM1=SUM1+TERM1                                                   00010500
      SUM2=SUM2+TERM2                                                   00010600
      SUM3=SUM3+M*TERM1                                                 00010700
      SUM4=SUM4+M*TERM2                                                 00010800
   80 CONTINUE                                                          00010900
      SUM3=SUM3*TERM                                                    00011000
      SUM4=SUM4*TERM                                                    00011100
      EXP1=CDEXP(2.*I*SQRTZB/3.)                                        00011200
      EXP2=EXP1*CONST1                                                  00011300
      EXP3=CONST2/EXP1                                                  00011400
      EXP4=CONST3*EXP1                                                  00011500
      EXP5=CONST4/EXP1                                                  00011600
      BETA=ALPHA/CDSQRT(RTZ)                                            00011700
      ZREAL=Z                                                           00011800
      ZIMAG=-I*Z                                                        00011900
      IF (ZREAL.GE.0.0.OR.ZIMAG.GE.0.0)GO TO 90                         00012000
      H1=BETA*(EXP2*SUM2+EXP5*SUM1)                                     00012100
      H1PRME=BETA*(EXP2*(SUM2*(-0.25/Z+I*RTZ)+SUM4)+EXP5*(SUM1*(-0.25/Z 00012200
     $       -I*RTZ)+SUM3))                                             00012300
      GO TO 110                                                         00012400
   90 H1=BETA*EXP2*SUM2                                                 00012500
      H1PRME=BETA*EXP2*(SUM2*(-0.25/Z+I*RTZ)+SUM4)                      00012600
  110 IF (ZREAL.GE.0.0.OR.ZIMAG.LT.0.0)GO TO 120                        00012700
      H2=BETA*(EXP3*SUM1+EXP4*SUM2)                                     00012800
      H2PRME=BETA*(EXP3*(SUM1*(-0.25/Z-I*RTZ)+SUM3)+EXP4*(SUM2*(-0.25/Z 00012900
     $       +I*RTZ)+SUM4))                                             00013000
      RETURN                                                            00013100
  120 H2=BETA*EXP3*SUM1                                                 00013200
      H2PRME=BETA*EXP3*(SUM1*(-0.25/Z-I*RTZ)+SUM3)                      00013300
      RETURN                                                            00013400
      END                                                               00013500
```

@PRT,S ARBNMCA.MAGANG

```
MORFITT*ARBNMCA(1).MAGANG
      SUBROUTINE MAGANG(ARG,AMAG,ANGLE)
      IMPLICIT REAL*8 (A-H,O-Z)
      COMPLEX*16 ARG
      DATA RDTDEG/5.729577951D1/
      ARGR-DREAL(ARG)
      ARGI=DIMAG(ARG)
      AMAG=CDABS(ARG)
      IF(ARGR .EQ. 0.0D0 .AND. ARGI .EQ. 0.0D0) GO TO 10
      ANGLE = DATAN2(ARGI,ARGR)*RDTDEG
      IF(ARGI .LT. 0.0D0) ANGLE=ANGLE+360.0D0
      RETURN
C
   10 ANGLE=0.0D0
      RETURN
      END

@PRT,S ARBNMCA.CURVE
```

MORFITT*ARBNMCA(1).CURVE

```
      SUBROUTINE CURVE(X,Y,   NRPTS,XMIN,YMIN,XINC,YINC,LINE)        CURVE001
C                                                                     CURVE002
C X,Y,UP MUST BE DIMENSIONED AT LEAST NRPTS                           CURVE003
C XMIN,YMIN ARE X,Y ORIGIN IN USER UNITS                              CURVE004
C XINC,YINC ARE X,Y SCALES IN USER UNITS PER INCH                     CURVE005
C                                                                     CURVE006
C LINE=1:  SOLID                                                      CURVE007
C      2:  LONG DASH                                                  CURVE008
C      3:  MEDIUM DASH                                                CURVE009
C      4:  SHORT DASH                                                 CURVE010
C      5:  DOTTED                                                     CURVE011
C      6:  SHORT + LONG DASH                                          CURVE012
C      7:  SHORT + SHORT + LONG DASH                                  CURVE013
C                                                                     CURVE014
      LOGICAL    UP1,UP2                                              CURVE015
      DIMENSION IPEN(10),JOC(7),X(NRPTS),Y(NRPTS)
      DATA IPEN/3,2,3,2,3,2,2,2,2,2/,JOC/18, 61, 56, 54, 52, 11, 36/  CURVE017
      DATA DELR/.1/,UP1/.FALSE./,UP2/.FALSE./                         CURVE018
C                                                                     CURVE019
      IF(LINE) 1,2,3
1     KK=MOD(LINE,7)+7
      GO TO 4
2     KK=0
      GO TO 4
3     KK=MOD(LINE,7)
4     KK=KK+1
      JO=JOC(KK)/10                                                   CURVE021
      JC=JOC(KK)-10*JO                                                CURVE022
C                                                                     CURVE023
      J=1                                                             CURVE024
      IP=2                                                            CURVEC25
      IF(KK .EQ. 6) IP=3                                              CURVE026
      DR=0.                                                           CURVE027
      RHO1=0.                                                         CURVE028
      RHO2=DELR                                                       CURVE029
      PX1=(X(1)-XMIN)/XINC                                            CURVE030
      PY1=(Y(1)-YMIN)/YINC                                            CURVE031
      IF(UP1) GO TO 10
C                                                                     CURVE033
C GO TO FIRST POSITION WITH PEN UP                                    CURVE034
      CALL PLOT(PX1,PY1,3)                                            CURVE035
C
10    DO 40 I=2,NRPTS
      PX2=(X(I)-XMIN)/XINC                                            CURVE037
      PY2=(Y(I)-YMIN)/YINC                                            CURVE038
      IF(UP2) GO TO 22                                                CURVE040
      IF(UP1) GO TO 37                                                CURVE041
      IF(KK .EQ. 2) GO TO 38                                          CURVE042
      DELX=PX2-PX1                                                    CURVE043
```

```
      DELY=PY2-PY1                                                      CURVE044
      RHO=SQRT(DELX**2+DELY**2)                                         CURVE045
      RHO1=RHO1+RHO                                                     CURVE046
      IF(RHO2 .GT. RHO1) GO TO 38                                       CURVE047
      DELX=DELX*DELR/RHO                                                CURVE048
      DELY=DELY*DELR/RHO                                                CURVE049
      DX 6=DELX*.1                                                      CURVE050
      DY 6=DELY*.1                                                      CURVE051
      IF(DR .EQ. 0.) GO TO 20                                           CURVE052
      DX=DELX*DR/DELR                                                   CURVE053
      DY=DELY*DR/DELR                                                   CURVE054
      PX1=PX1+DX                                                        CURVE055
      PY1=PY1+DY                                                        CURVE056
      GO TO 21                                                          CURVE057
   20 IF(RHO2 .GT. RHO1) GO TO 38                                       CURVE058
      PX1=PX1+DELX                                                      CURVE059
      PY1=PY1+DELY                                                      CURVE060
   21 CALL PLOT(PX1,PY1,IP)                                             CURVE061
      IF(KK .EQ. 6) CALL PLOT(PX1+DX6,PY1+DY6,2)                        CURVE062
      J=J+1                                                             CURVE063
      IP=IPEN(JO+MOD(J,JC))                                             CURVE064
      RHO2=RHO2+DELR                                                    CURVE065
      GO TO 20                                                          CURVE066
   22 DR=0.                                                             CURVE067
      RHO1=0.                                                           CURVE068
      RHO2=DELR                                                         CURVE069
      GO TO 39                                                          CURVE070
C PEN HAS BEEN UP, PREPARE TO LOWER PEN                                  CURVE071
   37 CALL PLOT(PX2,PY2,3)                                              CURVE072
      GO TO 39                                                          CURVE073
   38 CALL PLOT(PX2,PY2,IP)                                             CURVE074
      DR=RHO2-RHO1                                                      CURVE075
   39 PX1=PX2                                                           CURVE076
      PY1=PY2                                                           CURVE077
      UP1=UP2                                                           CURVE078
   40 CONTINUE                                                          CURVE079
      RETURN                                                            CURVE080
      END                                                               CURVE081

@PRT,S ARBNMCA.AXISM
```

MORFITT*ARBNMCA(1).AXISM

```
      SUBROUTINE AXISM (X,Y,BCD,NC,SIZE,THETA,XMIN,DX,TIC,NTIC)         AXI   1
C                                                                       AXI   2
C     (X,Y)       COORDINATES OF THE BEGINNING OF THE AXIS              AXI   3
C     BCD         ALPHANUMERIC ANRAY CONTAINING THE AXIS LABEL          AXI   4
C     NC          NUMBER OF CHARACTERS IN AXIS LABEL.  IF NC .GT. 0,    AXI   5
C                 THE AXIS ANNOTATION WILL BE ON THE COUNTER-CLOCKWISE  AXI   6
C                 SIDE OF THE AXIS.  NC .LT. 0 PLACES THE ANNOTATION ONAXI   7
C                 THE CLOCKWISE SIDE                                    AXI   8
C     SIZE        LENGTH OF THE AXIS IN INCHES                          AXI   9
C     THETA       THE ANGLE AT WHICH THE AXIS IS TO BE DRAWN            AXI  10
C     XMIN        THE VALUE OF THE COORDINATE AT THE BEGINNING OF THE   AXI  11
C                 AXIS.                                                 AXI  12
C     DX          THE CHANGE IN COORDINATE VALUE BETWEEN SUCCESSIVE     AXI  13
C                 LABELED TIC-MARKS.                                    AXI  14
C     TIC         THE DISTANCE BETWEEN TIC-MARKS, IN INCHES             AXI  15
C     NTIC        THE REPEAT CYCLE FOR PLACING COORDINATE VALUES AT     AXI  16
C                 TIC MARKS -                                           AXI  17
C                 .EQ. 1 CAUSES VALUES TO BE PLACED AT EVERY TIC-MARK   AXI  18
C                 .EQ. 2 CAUSES VALUES TO BE PLACED AT EVERY SECOND     AXI  19
C                        TIC MARK, ETC.                                 AXI  20
C                 .EQ. 0 SUPPRESSES ALL COORDINATE VALUES               AXI  21
C                                                                       AXI  22
C     J MARTIN    JUNE 1966                                             AXI  23
C                                                                       AXI  24
      DIMENSION BCD(2)                                                  AXI  25
      INTEGER ALPHA(2)                                                  AXI  26
         DATA ALPHA(1)/'(X10'/,ALPHA(2)/'  ) '/                         DMP
      SYGN=1.0                                                          AXI  27
      IF (NC) 5,10,10                                                   AXI  28
    5 SYGN=-1.0                                                         AXI  29
   10 NAC=IABS(NC)                                                      AXI  30
      SWITCH=0.0                                                        AXI  31
      TH=THETA*0.01745329                                               AXI  32
      CTH=COS(TH)                                                       AXI  33
      STH=SIN(TH)                                                       AXI  34
      DXT=TIC*CTH                                                       AXI  35
      DYT=TIC*STH                                                       AXI  36
      N=SIZE/TIC                                                        AXI  37
      TN=N                                                              AXI  38
      XB=X                                                              AXI  39
      YB=Y                                                              AXI  40
      XA=X-0.05*SYGN*STH                                                AXI  41
      YA=Y+0.05*SYGN*CTH                                                AXI  42
      CALL PLOT (XA,YA,3)                                               AXI  43
C         DRAW TICS.*                                                   AXI  44
      DO 15 I=1,N                                                       AXI  45
      CALL PLOT (XB,YB,2)                                               AXI  46
      XC=XB+DXT                                                         AXI  47
      YC=YB+DYT                                                         AXI  48
```

```
      CALL PLOT (XC,YC,2)                                          AXI  49
      XA=XA+DXT                                                    AXI  50
      YA=YA+DYT                                                    AXI  51
      CALL PLOT (XA,YA,2)                                          AXI  52
      XB=XC                                                        AXI  53
   15 YB=YC                                                        AXI  54
      IF (NTIC) 25,20,25                                           AXI  55
   20 EXPX=0.0                                                     AXI  56
      GO TO 90                                                     AXI  57
   25 ADX=ABS(DX)                                                  AXI  58
C         CALCULATE VALUE OF LAST LABELED TIC.*                    AXI  59
      ABSV=XMIN+DX*N/NTIC                                          AXI  60
      EXPX=0.0                                                     AXI  61
      IF (ADX) 30,90,30                                            AXI  62
   30 IF (ADX-100.0) 45,35,35                                      AXI  63
   35 ADX=ADX/10.0                                                 AXI  64
      ABSV=ABSV/10.0                                               AXI  65
      EXPX=EXPX+1.0                                                AXI  66
      GO TO 30                                                     AXI  67
   40 ADX=ADX*10.0                                                 AXI  68
      ABSV=ABSV*10.0                                               AXI  69
      EXPX=EXPX-1.0                                                AXI  70
   45 IF (ADX-0.01) 40,90,90                                       AXI  71
   50 M=N                                                          AXI  72
      MM=N+1                                                       AXI  73
      DO 65 I=1,MM                                                 AXI  74
      K=MM-I                                                       AXI  75
      AK=FLOAT(K)/FLOAT(NTIC)-FLOAT(K/NTIC)                        AXI  76
      IF (AK) 55,60,55                                             AXI  77
   55 XB=XB-DXT                                                    AXI  78
      YB=YB-DYT                                                    AXI  79
      ABSV=ABSV-(ADX/NTIC)
      GO TO 65                                                     AXI  80
   60 XA=XB-(0.20*SYGN-0.05)*STH-0.17143*CTH                       AXI  81
      YA=YB+(0.20*SYGN-0.05)*CTH-0.17143*STH                       AXI  82
      GO TO 70                                                     AXI  83
   65 CONTINUE                                                     AXI  84
   70 N=K/NTIC+1                                                   AXI  85
      DO 80 I=1,N                                                  AXI  86
C         LABEL TICS, IN REVERSE ORDER.*                           AXI  87
      CALL NUMBER (XA,YA,0.1,ABSV,THETA,2)                         AXI  88
      ABSV = ABSV - ADX
      XA=XA-DXT*FLOAT(NTIC)                                        AXI  90
      YA=YA-DYT*FLOAT(NTIC)                                        AXI  91
      IF (SWITCH) 80,75,80                                         AXI  92
   75 CALL WHERE (XW,YW,FACT)                                      AXI  93
      D1=SQRT((XW-XT)**2+(YW-YT)**2)                               AXI  94
      D2=SQRT((XW-XA)**2+(YW-YA)**2)                               AXI  95
      IF (D1-D2) 110,110,80                                        AXI  96
   80 CONTINUE                                                     AXI  97
```

```
85    RETURN                                                        AXI  98
90    IF (EXPX) 95,100,95                                           AXI  99
95    TNC=NAC+7                                                     AXI 100
C ***** THE NEXT TWO STATEMENTS HAVE BEEN REPLACED BY DATA          DMP
C ***** STATEMENTS BECAUSE THE CHARACTERS DESIRED DO NOT HAVE       DMP
C ***** THE SAME INTEGER EQUIVALENTS ON THE 1110                    DMP
C     ALPHA(1)=240+256*(241+256*(231+256*77))                       DMP
C     ALPHA(2)=64+256*(93+256*(64+256*64))                          DMP
      GO TO 105                                                     AXI 103
100   TNC=NAC                                                       AXI 104
105   XT=X+(SIZE/2.0-0.07*TNC)*CTH-(-0.07+SYGN*0.4225)*STH          AXI 105
      YT=Y+(SIZE/2.0-0.07*TNC)*STH+(-0.07+SYGN*0.4225)*CTH          AXI 106
      IF (NTIC) 50,110,50                                           AXI 107
C         DRAW AXIS NAME.=                                          AXI 108
110   CALL SYMBOL (XT,YT,0.14,BCD(1),THETA,NAC)                     AXI 109
      IF (EXPX) 120,115,120                                         AXI 110
115   SWITCH=1.0                                                    AXI 111
      IF (NTIC) 80,85,80                                            AXI 112
120   XT=XT+((TNC-6.0)*0.14)*CTH                                    AXI 113
      YT=YT+((TNC-6.0)*0.14)*STH                                    AXI 114
      CALL SYMBOL (XT,YT,0.14,ALPHA(1),THETA,7)                     AXI 115
      XT=XT+0.56*CTH-0.07*STH                                       AXI 116
      YT=YT+0.56*STH+0.07*CTH                                       AXI 117
      CALL NUMBER (XT,YT,0.10,EXPX,THETA,-1)                        AXI 118
      GO TO 115                                                     AXI 119
      END                                                           AXI 120-
```

@PRT,S ARBNMCA.CLINEQ

MORFITT*ARBNMCA(1).CLINEQ

```
      SUBROUTINE CLIN EQ (A, B, X, N,
     $   N DIM, IFLAG, ERR)
C
C   CLIN EQ USES L-U DECOMPOSITION TO
C   FIND THE TRIANGULAR MATRICES L, U
C   SUCH THAT  L * U = A.  L AND U ARE
C   STORED IN A.  THIS FORM IS USED WITH
C   BACK-SUBSTITUTION TO FIND THE SOLN
C   X OF   A * X = L * U * X = B.
C   N IS THE NUMBER OF EQUATIONS AND
C   N DIM IS THE DIMENSION OF ALL ARRAYS
C   IN THE PARAMETER LIST.
C
C   IF IFLAG = 0, L, U, AND X ARE
C   COMPUTED.
C   IF IFLAG IS NON-ZERO, IT IS ASSUMED
C   THAT L AND U HAVE BEEN COMPUTED IN
C   A PREVIOUS CALL AND ARE STILL STORED
C   IN A.  THUS ONLY X IS COMPUTED.
C   ERR  IS THE ESTIMATED RELATIVE
C   ERROR OF THE SOLUTION VECTOR.
C
      COMPLEX*16  A, B, X, T
      INTEGER*4  IROW
      DIMENSION  A(N DIM, N DIM),
     $  B(N DIM), X(N DIM)
      DIMENSION  IROW(50), Q(50)
      DATA  EPS /1.0E-15/
C
C
      IF (N.GT.50)  GO TO 900
      IF (IFLAG.NE.0)  GO TO 600
      DO 050  I = 1,N
      Q(I) = 0.0
      DO 040  J = 1,N
      QQ = CDABS (A(I,J))
  040 IF (Q(I).LT.QQ)  Q(I) = QQ
      IF (Q(I).EQ.0.0)  GO TO 901
  050 CONTINUE
      ERR = EPS
      PPIV = 0.0
      DO 100  I = 1,N
  100 IROW(I) = I
C
      DO 500  L = 1,N
      PIVOT = 0.0
      K = L - 1
      DO 240  I = L,N
      IF (K.LT.1)  GO TO 230
```

```
      DO 220  J = 1,K
  220 A(I,L) = A(I,L) - A(J,L) * A(I,J)
  230 F = CDABS (A(I,L)) / Q(I)
      IF (PIVOT.GT.F)  GO TO 240
      PIVOT = F
      NPIVOT = I
  240 CONTINUE
      IF (PIVOT.EQ.0.0)  GO TO 901
      IF (PPIV.LE.PIVOT)  GO TO 250
      ERR = ERR + PPIV / PIVOT
      IF (ERR.GE.1.0)  GO TO 901
  250 PPIV = PIVOT
      IF (NPIVOT.EQ.L)  GO TO 280
      Q(NPIVOT) = Q(L)
      J = IROW(L)
      IROW(L) = IROW(NPIVOT)
      IROW(NPIVOT) = J
      DO 260  I = 1,N
      T = A(L,I)
      A(L,I) = A(NPIVOT,I)
      A(NPIVOT,I) = T
  260 CONTINUE
  280 IF (L.EQ.N)  GO TO 500
      T = (1.0D0,0.0D0) / A(L,L)
      K = L + 1
      M = L - 1
      DO 450  I = K,N
      IF (M.LT.1)  GO TO 400
      DO 350  J = 1,M
  350 A(L,I) = A(L,I) - A(L,J) * A(J,I)
  400 A(L,I) = T * A(L,I)
  450 CONTINUE
  500 CONTINUE
      IF (ERR.GT.1.0E-5)   PRINT 998, ERR
C
C
  600 DO 620  I = 2,N
  620 X(I) = (0.0D0,0.0D0)
      J = IROW(1)
      X(1) = B(J) / A(1,1)
      DO 700  I = 2,N
      J = IROW(I)
      K = I - 1
      DO 650  L = 1,K
  650 X(I) = X(I) + A(I,L) * X(L)
      X(I) = (B(J) - X(I)) / A(I,I)
  700 CONTINUE
      K = N - 1
      DO 800  I = 1,K
      J = N - I
```

```
      M = J + 1
      DO 800  L = M,N
      X(J) = X(J) - X(L) * A(J,L)
  800 CONTINUE
      RETURN
C
  900 PRINT 999
      ERR = 1.0
      RETURN
  901 PRINT 997
      ERR = 1.0
      RETURN
  997 FORMAT ('1ERROR IN CLIN EQ, MATRIX IS SINGULAR')
  998 FORMAT (' CAUTION-',
     $ ' CLIN EQ HAS DECOMPOSED AN ILL-CONDITIONED MATRIX.',/,
     $ ' RESULTS WILL HAVE RELATIVE ERROR =',E11.2)
  999 FORMAT ('1ERROR IN CLIN EQ, MATRIX SIZE GREATER THAN 50')
      END

@PRT,T ARBNMCA.
```

MORFITT*ARBNMCA(1)   ELEMENT TABLE

D	NAME	VERSION	TYPE	DATE	TIME	SEQ #	SIZE-PRE,	TEXT	(CYCLE	WORD)		PSRMODE	LOCATION
	HTGAIN		FOR SYMB	29 MAR 79	09:09:08	1		37	5	0	1		1792
	HTGAIN		RELOCATABLE	29 MAR 79	09:09:13	2	3	56				QTR	1829
	HTINTL		FOR SYMB	29 MAR 79	09:09:21	3		103	5	0	1		1888
	HTINTL		RELOCATABLE	29 MAR 79	09:09:32	4	3	148				QTR	1991
	CURVE		FOR SYMB	29 MAR 79	09:10:12	5		43	5	0	1		2142
	CURVE		RELOCATABLE	29 MAR 79	09:10:13	6	2	17				QTR	2185
	AXISM		FOR SYMB	29 MAR 79	09:10:17	7		67	5	0	1		2204
	AXISM		RELOCATABLE	29 MAR 79	09:10:20	8	2	31				QTR	2271
	MDHNKL		FOR SYMB	29 MAR 79	09:10:27	9		73	5	0	1		2304
	MDHNKL		RELOCATABLE	29 MAR 79	09:10:33	10	2	93				QTR	2377
	MAGANG		FOR SYMB	29 MAR 79	09:10:35	11		9	5	0	1		2472
	MAGANG		RELOCATABLE	29 MAR 79	09:10:36	12	2	4				QTR	2481
	CLINEQ		FOR SYMB	29 MAR 79	09:10:41	13		63	5	0	1		2487
	CLINEQ		RELOCATABLE	29 MAR 79	09:10:43	14	2	46				QTR	2550
	MCSTEP		FOR SYMB -Q	23 JUL 79	09:32:17	15		73	5	0	1		2598
	MCSTEP		RELOCATABLE	23 JUL 79	09:32:19	16	4	28				QTR	2671
	ACCUMA		FOR SYMB -Q	19 NOV 79	10:47:02	17		196	5	0	1		2703
	ACCUMA		RELOCATABLE	19 NOV 79	10:47:23	18	4	92				QTR	2899
	MAIN		FOR SYMB -Q	10 JAN 80	15:04:56	19		275	5	0	1		2995
	MAIN		RELOCATABLE	10 JAN 80	15:05:34	20	7	151				QTR	3270
	MCFLD		FOR SYMB -Q	10 JAN 80	15:05:55	21		124	5	0	1		3428
	MCFLD		RELOCATABLE	10 JAN 80	15:06:59	22	5	71				QTR	3552
	MCPLTS		FOR SYMB -Q	15 JAN 80	10:24:00	23		69	5	0	1		3628
	MCPLTS		RELOCATABLE	15 JAN 80	10:24:17	24	4	61				QTR	3697
	PGM		MAP SYMB	15 JAN 80	10:24:17	25		1	5	0	1		3762
	PGM		ABSOLUTE	15 JAN 80	10:24:17	26		783				QTR	3763

NEXT AVAILABLE LOCATION- 4546

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